A COMPARISON OF THE ECOLOGY OF FALLOW DEER (*Dama dama* L.), CATTLE AND SHEEP ON A SHARED RANGELAND

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1985

I hereby declare that this thesis has been composed by me from the results of my own work, except where otherwise stated, and that no part has been presented for a higher degree.

Abdul Aleem Chaudhary

Dedicated to the memory of my mother

ABSTRACT

Hopetoun House Deer Park is mainly utilized by fallow deer. Cattle and sheep share the range during the summer. The objective of the study was to compare the foraging ecology of fallow deer, cattle and sheep. The distribution of herbivores on the range was compared with the distribution of plant species and broad categories of habitat. All herbivores showed positive associations with *Lolium*. Fallow does generally preferred tree groves, and sheep grassland. Fallow bucks and cattle preferred shaded areas during summer. In all seasons herbivores spent more time grazing than resting during the day. Different herbivores showed different patterns of diurnal habitat use. Sheep during summer preferred to graze in the shaded areas and used grasslands for resting early in the morning and late in the afternoon. The diet of herbivores was determined by microhistological analysis of faecal pellets. Food plant species in the diet of herbivores were similar but their proportions differed. Cattle and sheep consumed more grasses and less forbs than fallow bucks and does. The nutritional quality of the forage plant species was determined on clipped forage samples, and the total diet quality calculated by using proportions of food plant species in the diet. The diet was considered adequate nutritionally, hence the suggestion that multiple species grazing was not adversely affecting the diet quality of herbivores on the range. It was, therefore, concluded that 'multiple species' use of a rangeland, such as that at Hopetoun, at a suitable stocking level could result in increased utilization of the available forage and consequently increased productivity.

ACKNOWLEDGEMENTS

I wish to thank the British Council and the Government of the Punjab (Pakistan), Forestry and Wildlife Department for financial support, and Mr. Douglas-Menzies, Factor, Hopetoun House Estate for permission to work in the Deer Park.

I would also like to thank the following persons: Dr. I. R. Taylor, my supervisor, for his continuous encouragement and guidance throughout this work, for his invaluable comments on the draft of this thesis and for his patient corrections of my English; Dr. J. Grace for his help with vegetation surveys and analysis, and with Principal Component Analysis; Geoff Cohen of Department of Statistics, University of Edinburgh for his timely help in complex statistical analyses; Dr. R. Meutzefeldt, for help in sorting out computational problems; Dr. J. Hodgson of HFRO for his suggestions and comments on the study; Dr. Peter Jones for many a useful pieces of advice, Dr. W. E. S. Mutch, Head of the Department, for his continuous encouragement; Baxter Cooper for some good discussions; Dr. and Mrs. Richard Ennos for all their friendship; Dr. C. Legg, Nigel Harding and Kenneth Grierson for their help in making some computer programmes; Dr. D. Bullock of St. Andrews University for lending me his slides of reference plant material; Dr. N. Easterbee of Nature Conservancy Council, for his guidance in faecal pellet analysis; Robin Seller of HFRO for his assistance in determining digestibility co-efficients and Andy Gray for his help in conducting nutritional content analysis on food plant species; Mr. R. Thomson, Gamekeeper Hopetoun House, for his continuing support during my field work; Dave Haswell for all the photographs and photomicrographs; Alison Wood for her friendship, and help in getting me all the rare books and papers and Margaret Jackson for her friendliness and typing this thesis; and ever helpful staff of Department of Forestry and Natural Resources : Mrs. Jean Saunders, Mrs. Jackie Ewart, Anne Cuthbertson, Jeremy Landless, Alex Harrower, Dave Mackenzie, Derek Scott, Patrick McCann and Jimmy McGhee; and the advisory staff of ERCC.

I am also grateful to Fiona Slack for her friendship and for bearing with my appalling driving, Jane Whitbread and Eleanor Urquhart for their help in vegetation survey.

I would like to thank my fellow students in the Department for sharing moments of tension and relief, especially Mahfooz-Al-Salman, Ali Al-Thwadi (also for his financial help), Ali Kazim Radhi, Brian Titus and of course my fellow late-night worker, now Dr. Karen Ross.

I also wish to thank my fellow Pakistani students who were a source of constant friendship and goodwill during my stay in Edinburgh - now Drs. M. Rasool Khan, Qibla Ayaz and Muhammad Suleman; Abdul Latif Rao, Ashiq Ahmad Khan and Munir Ahmad Awan; Mahmood Ahmad Satti and his wife Dr. Surayya Mahmood, and my friend Munir Ahmad and his family in London for their much appreciated help in many different ways.

My indebtedness also goes to my teacher, Dr. G. M. Khattak, ex Director General of Pakistan Forest Institute Peshawar, and to Mr. M. I. Sheikh, the present Director General, for priming me into research, being helpful all through my stay at PFI, and helping me to the award of this fellowship. I am also grateful to Dr. Javed Ahmad and Amjad Chima for sorting out some of the service problems in the Punjab Forest Department.

I am thankful to my father who allowed me to leave him in his old age and come here in the pursuit of this degree, and my elder sister Mrs. Munir Ashraf in particular and all my family back home for all the good wishes they had for me and for all that they had to face because of my absence from home.

And can I thank my wife and kids - Hamza and Sarah. My wife Saeeda has always been a good companion and a source of encouragement throughout our stay in Britain. She has lived patiently with all my changing moods of ups and downs during this study. My son and

daughter, though did not get their due attention, yet they were a constant source of enjoyment in otherwise somewhat bleak days.

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1 INTRODUCTION

1. INTRODUCTION

The fallow deer (*Dama dama* L.) was reintroduced into Britain in Norman times for aesthetic reasons and for hunting. In the 18th Century with the development of parkland around stately homes, fallow deer were maintained mainly for aesthetic purposes. In 1892, 390 parks in England and 4 in Scotland had fallow deer herds (Whitaker 1892, Whitehead 1964). This number has now decreased considerably and Chapman and Chapman (1975) reported a total of 117 herds. In some cases, the fallow deer are now maintained as a part of mixed grazing regimes, usually with cattle (*Bos taurus*) and sheep (*Ovis aries*).

In some parks, they are still kept simply as decoration but there is now a growing interest in utilizing them for high quality meat production, in conjunction with domestic livestock. The ecology of a mixed species grazing system involving fallow deer and domestic stock has not yet been studied and the purpose of the study reported here was to examine one such system.

Several other grazing regimes involving other species of deer and livestock have already been examined. In general, these have demonstrated that multiple species use of rangeland results in an increased utilization of the available forage and consequently increased productivity. McMahan and Ramsey (1965) after conducting a series of experiments on common-use grazing under various grazing systems by white-tailed deer (*Odocoileus virginianus*) and livestock on the Edwards Plateau in Texas indicated that the range could be efficiently used by running one or several classes of livestock with deer in order to harvest the forage not utilized by deer. With moderate stocking rates they also obtained increased livestock production per animal and a net return per animal unit. From the same area Ramsey (1965) also indicated a higher potential economic return from marketing hunting priviliges for the white- tailed deer than that from livestock production. On the same area Bryant *et al.* (1979) also showed a degree of complementarity in the pattern of use of rangeland

by white-tailed deer, sheep, and Angora and Spanish goats (*Capra hircus*). Sheep diets consisted of grasses followed by browse, goats consumed about equal amounts of grass and browse, and the deer spent most of their feeding time on browse followed by forbs. The deer, however, made higher use of grass regrowth after July when the livestock were removed from the range for 4 months. During winter when the least browse was present on the range, the livestock started to take dry grass which, though, available in plenty was not eaten by the deer. Merrill and Young (1954), and Huss and Allen (1969 - in Litt. - Bryant *et al*.1979) reported common use grazing by deer and livestock in the same area as economically beneficial.

Browse is the main forage consumed from low-elevation forests in northern Idaho, U.S.A., the yearlong range of the white-tailed deer and spring-summer-fall range of cattle (Thilenius and Hungerford 1967). Though the same browse species were eaten both by cattle and deer, most species were taken in greatly different amounts. The use by cattle did not lower the food supply for deer during winter. Rather it may have been advantageous for deer in increasing the production of elongated, basal stems which were the plant parts most used by the deer. Complementary use of grasses by cattle and browse by mule deer (*Odocoileus hemionus*) on shared rangeland has also been reported from other areas by various authors e.g., from north central Montana by Dusek (1975), and from north western Colorado by Lucich and Hansen (1981).

Herbivores are also known to achieve complementarity through habitat partitioning. McLean and Willms (1982) indicated that mule deer on rangeland in Kamloops, British Columbia avoided competition with cattle for grass in early spring (when it was the most intense) by inhabiting gullies and sloping areas whereas the cattle mainly occupied flat areas. Black-tailed deer (*Odocoileus hemionus columbiana*) on Sierra Foothill ranges of California occupied brush areas; cattle occupied open plains and feral hogs (*Sus scrofa*) utilized the irrigated pastures (Barrett 1982).

Hudson *et al.* (1976) showed that the use of rangelands by cattle from June to October on Premier Ridge of the Rocky Mountains, SE British Columbia, was not significantly affected by wild herbivores distribution during winter, neither directly nor as affected through changes in vegetation. The herbivores involved, white-tailed deer, mule deer, elk (*Cervus canadensis nelsoni*) and big horn sheep (*Ovis canadensis*), also exhibited distinct patterns of utilization during winter (November-May). White-tailed deer occupied areas with gentler slopes at lower elevations bearing Douglas-fir (*Pseudotsuga menzesii*) - lodgepole pine (*Pinus contorta*) forests, whereas the mule deer occupied more rugged slopes at higher elevations, utilized open shrublands with good stands of highly grazed bunch wheatgrass (*Agropyron spicatum* var. *inerme*). Elk showed no association with habitat patterns while bighorn sheep showed a localized distribution, occupying rugged terrain at intermediate elevations supporting moderate stands of bunch grass with scattered trees, shrubs, rock outcrops and non cespitose grasses.

The grazing behaviour of blackface sheep and red deer (*Cervus elaphus*) has been compared in Perthshire, Scotland (Colquhoun 1971). Though the plant species consumed by the sheep and deer were the same, the proportions of each species in their diets were significantly different. Also they differed significantly in the extent of their use of different vegetation types. The deer and sheep also exhibited different distribution and movement patterns according to elevation. Thus, he suggested, that the dual use of vegetation was more than it would have been under monospecific use, and that the carrying capacity of the range increased with the dual use grazing system.

Clear differences were shown in habitat use by sheep, red deer hinds and stags on Ardtornish, Scotland (Osborne 1984). *Agrostis-Festuca* swards were used more by sheep than by hinds (50 % and 15 % of their time respectively). Sheep remained on the lower altitudes whereas the hinds were observed over a wide range of altitudes. Stags spent 95 % of their time at intermediate altitudes and less productive

sites. Sheep most selected mesotrophic communities, hinds were less selective whereas the stags avoided mesotrophic communities and selected, though weakly, oligotrophic communities.

Smith *et al.* (1979) compared the winter use by mule deer of two experimental pastures in Utah. One of the pastures was grazed by sheep (sheep-deer pasture) in late spring (late May and early June) for a 20-day period. The other pasture (deer-only pasture) was not grazed by sheep. Total herbaceous matter on the sheep-deer pasture decreased after late spring sheep grazing but green herbaceous matter increased as a result of regrowth following fall precipitation. Release of moisture and nutrients due to herbaceous plant removal by sheep also resulted in an increase in current year's shrub growth especially that of *Prushia tridentata* (bitterbrush), the most important dietary item for deer during winter. The total stocking rate of the sheep-deer pasture (100 deer days/ha + 150 sheep days/ha) was almost double that of the deer-only pasture (100 deer days/ha) thus showing a potential for increased animal production per unit of land under dual use grazing.

The ecological aspects of the use of grassland systems by communities of wild herbivores have been studied extensively especially in East Africa (Lamprey 1963, Talbot 1964, Vesey-Fitzgerald 1965, Bell 1971, Jarman and Sinclair 1979, Maddock 1979). A large number of species can share the same system by virtue of differences in their foraging ecology thus leading to a higher overall productivity than would be obtained by any species on its own. Such differences involve vertical and horizontal stratification, differential selection of plant species and of parts of individual species. In some instances, such as the Serengeti plains, there is a succession of herbivores in which species are dependent upon conditions created by others (Bell 1971, Maddock 1979).

Mishra (1982) studied the habitat utilization patterns of sympatric cervid species in Chitwan National Park, Nepal. Chital

(*Axis axis*), the main deer species in the area, occupied riverine forest/grassland edge varying their choice of habitat with stages of plant growth, grass cutting and seasonal burning. The hog deer (*Axis porcinus*) utilized grasslands whereas the habitat use by sambar (*Cervus unicolor*) and the barking deer (*Muntiacus muntjak*) was mainly restricted to forest habitats.

Mixed grazing systems involving only domestic species have also been studied in detail. In most grazing experiments involving cattle and sheep output per unit area was found to be higher in mixed species grazing than in single species grazing (reviewed by Nolan and Connolly 1977). This advantage was attributed to improved performance or to improved herbage utilization from the consumption by one kind of livestock of the herbage rejected by others (Peart 1962, Cook, *et al.* 1967, Bedell 1968, Dudzinski and Arnold 1973, Hamilton 1975). An improved performance of 10 % by heifers and 17 % by lambs on mixed grazing was reported by Ocokoljic *et al.* (1969, in Litt. Nolan and Connolly 1977).

Peart (1962) obtained an 18-37 % increase in output per unit area where cattle were introduced on Cheviot hill grasslands in Scotland, used by sheep. Reynolds *et al.* (1971) also obtained a 9 % increase in liveweight gain per unit area when grazing sheep and cattle at Agricultural Research Station Beltsville, Maryland, U.S.A. in 1:1 ratio as compared to single species grazing. Increased output in sheep production in mixed grazing at Sourhope, Cheviot Hills, Scotland was attributed to the effect of complementary grazing - cattle consuming the coarse herbage and sheep using the more nutritious diet rejected by the cattle (Peart 1962).

All of the above studies have shown that associations of herbivores can result in higher productivity than single species systems, through the complementarity of their forage ecology.

The specific objective of the present study was to compare the

foraging ecology of fallow deer, cattle and sheep sharing an area of open parkland habitat. This involved comparisons of their distribution in relation to the plant communities available, their selection of food species and their general grazing behaviour. The nutritional quality of forage available and of that selected by the herbivores was also examined.

2 STUDY AREA

2. STUDY AREA

Hopetoun House estate is situated 20 km NW of Edinburgh on the southern bank of Firth of Forth. Fallow deer were introduced into the parkland around the house about the start of the 19th century and the present deer park was enclosed by the middle of the 19th century (Fig. 2.1). The park covers an area of 54 ha.

The topography of the park is undulating. The highest point, 75 m a.s.l. is on the southern side, and the lowest, less than 20 m a.s.l. on the extreme north western side. In the south west corner there is a water reservoir of about one ha which is fenced off from the livestock. Excess water is drained out of the reservoir to the north through an issues. There is another issues located on the north western side of the park. The flow is normally reduced to a trickle in summer. Water is also available from a pond, situated near the remains of the Staneyhill Tower in the centre of the southern side of the park. Two other water points have been provided on the range, one on the eastern side of the park near the old quarry, and the other on the western side into the sheepfold.

The park area is blanketed by thick deposits of clayey tills obscuring the underlying rocks which belong mainly to the carboniferous sedimentary stratum including shales and sandstones with some coal and occasional limestones and calciferous sandstones (Brown and Shipley, eds. 1982). The area falls in the main soil association, Kilmarnock and the subsidiary association Ashgrove. Parent material is the drifts derived mainly from shales of carboniferous age, and the component soils are brown forest soils with gleying, developed on clayey tills. Some gleying features are also present in the B horizon which render the soils acidic.

The soils in the park are, however, slowly permeable under a low rainfall regime. Brown and Shipley (1982) have reported that though

Fig. 2.1 Map of Hopetoun House Deer Park.

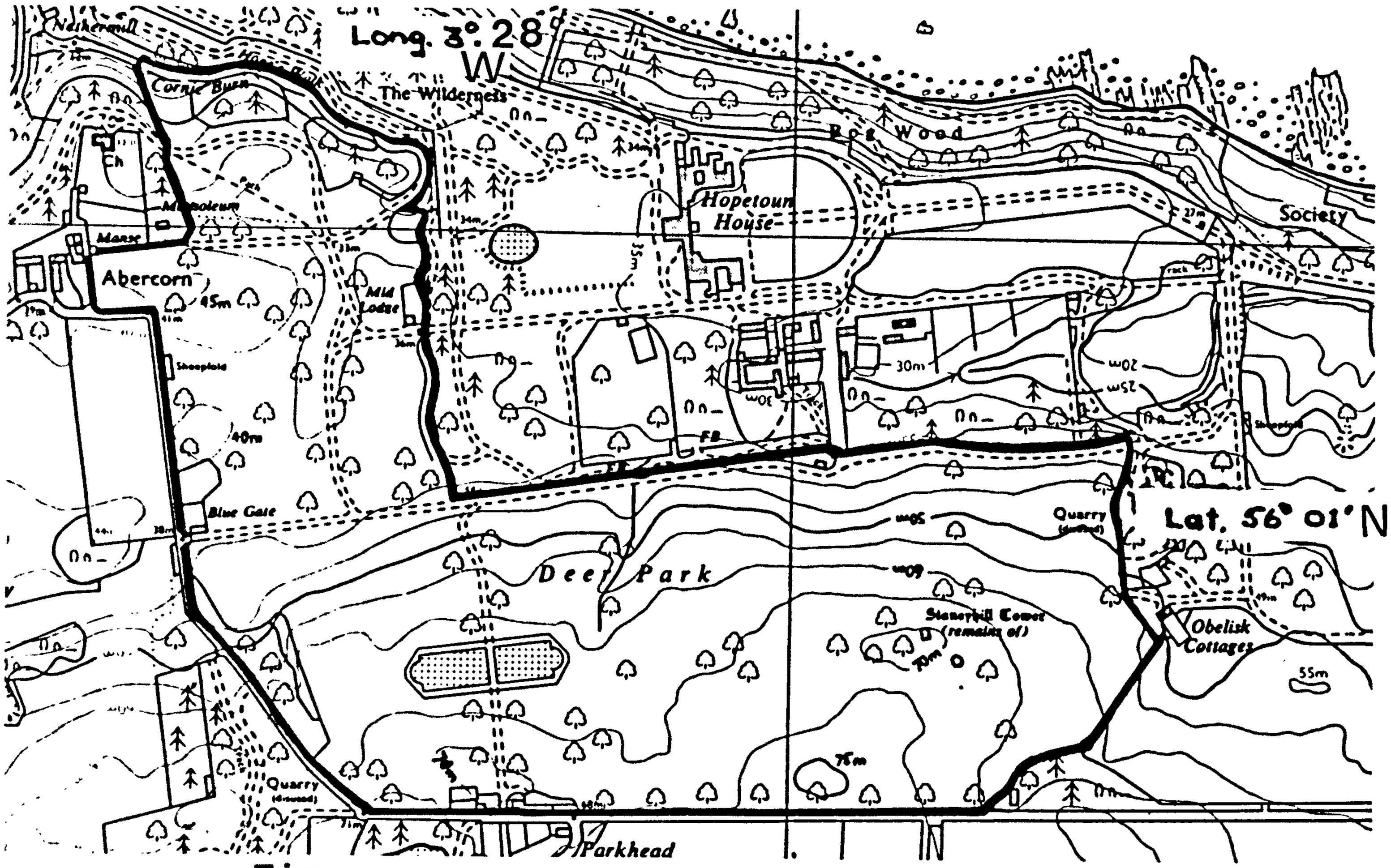

Long. 3° 28' W
Lat. 56° 01' N
Nethermill
Corrie Burn
The Wilderness
Bog Wood
Hopetoun House
Society
Mausoleum
Manse
Abercorn
45m
Mill Lodge
Sheepfold
40m
Blue Gate
Deer Park
Quarry
Stanephill Comet (remains of)
Obelisk Cottages
55m
75m
Parkhead
30m
25m
20m

Fig. 2.1

such soils are slowly permeable, soil moisture is at field capacity level only for 150 days or less in most years, and high levels of deficit develop in summer. Out of season high rainfall and plastic conditions in the wet soil can cause problems in some years. Because of slow permeability, the land retains moisture as well as the nutrients thus providing an ideal state for growth. The land is considered suitable for producing consistently high yields of a narrow range of crops (cereal and grasses). Short grass leys is the recommended use for such land types.

Soils of the park were analysed at East of Scotland College of Agriculture in 1982. Only phosphorus was found to be deficient. As a result 150 kg P_2O_5 was spread over the main part of the range.

Climatic records are available for Edinburgh (Turnhouse) airport, only 8 km from the study site. Average annual rainfall (over 22 years : 1949-1970) is 677 mm. Peak rainfall occurs in late summer (32 % in July to September), winter is moderately wet (34 % in October to January), and the spring and early summers are dry (34 % in 5 months, February to June). Mean annual temperature is 8.5 °C (4.9-12.0 °C). The growing season, conventionally the period with mean temperature > 5.6 °C is in the range of 225-250 days. Average annual duration of bright sunshine is 1294.2 hours and a daily mean 3.54 hours. Average daily relative humidity (%) at 0900 hours varies from 73.3 in July to 84.6 in December and January (average of the period 1962- 80). Wind speed may vary from no wind to >116 km per hour. Wind direction is mainly western, 41 % of the times in the year, followed by eastern and southern (20 % and 14 % of the times in the year), wind blowing from the north only 10 % of the times. During the study period, percent yearly frequency of winds blowing from west was 36 %, from south 31 %, from east 17 %, and that from the north 16 %. Average evapo-transpiration values for the region are 470 mm (for East-Lothian, Brown and Shipley 1982). Haar (fog in the coastal areas) in spring and early summer also affects the amount of sunshine, moisture and warmth in the air. The incidence of frost has not been

documented in literature but being proximal to the sea, the intensity could be low.

Vegetation in the park is typical of a ley or permanent pasture, with a high proportion of perennial ryegrass (*Lolium perenne*) in the *Lolio-Cynosuretum* (Birse 1980) grass association. Some poorly drained sites contain foxtail (*Alopecurus pratensis*). Due to persistent use, and in the absence of any fertility development measures, fertility has deteriorated, and species like meadow grass (*Poa annua* and *P. trivialis*), sweet vernal (*Anthoxanthum odoratum*), common bent (*Agrostis tenuis*), Yorkshire fog (*Holcus lanatus*), and tufted hair grass (*Deschampsia cespitosa*) have established themselves. Other important grasses established in the area are red fescue (*Festuca rubra*), timothy (*Phleum pratense*), cocksfoot (*Dactylis glomerata*) and oat grass (*Arrhenatherum elatius*).

White clover (*Trifolium repens*) has established itself on the range and gives it a *Lolium*-clover character in places. At sunny places *Ranunculus ficaria* is the first forb to make its appearance followed by daisy (*Bellis perennis*). Buttercup (*R. repens*) occurs in shady places, whereas *Prunella vulgaris* is found on open deteriorated sites. Thistle (*Cirsium vulgare*) and nettle (*Urtica dioica*) grow on moister and shaded sites.

Tree groves were established on the park to provide shelter for the animals and for amenity purposes. Single trees were also planted on the range at varying distances (Fig. 2.2). Most of trees are now mature or overmature and some have already been felled with saplings planted as replacements. Solitary saplings have been fenced against the browsing damage. Two tree groves have been fenced to keep the cattle and sheep out. The deer, however, are not excluded. New planting over an area of about 0.2 ha was done in April 1983, with 1 m high saplings of oak (*Quercus petrae, Q. robur*), ash (*Fraxinus excelsior*), acer (*Acer pseudoplatanus*), beech (*Fagus sylvaticus*), horse chestnut (*Aesculus hippocastaneum*). The saplings were provided

Fig. 2.2 Hopetoun House Deer Park. An aerial view.

with spiral tree guards against the damage by rabbits and squirrels and the area was fenced against deer damage.

At the time of the start of the study, in September 1982, the fallow deer herd in the park numbered 56 - 8 bucks, 26 does, 11 yearlings and 11 fawns. During winter 1982, 2 bucks and 12 does were culled as the annual routine (changed in 1980 replacing the biennial practice of culling). 5 prickets (fallow yearling males), out of 11 yearlings joined the buck group. Total herd during the winter and spring 1983 was thus 42 (11 bucks, 20 does, and 11 fawns). 16 fawns were born in 1983 fawning season (June/July 1983). 8 bucks and two yearling males were culled in late summer 1983, leaving only 3 oldest bucks to take part in the rut (in October/November). The herd size in the autumn 1983 was 48 (3 bucks, 20 does, 9 yearlings and 16 fawns).

250 North country Cheviot sheep and mixed breed sheep graze the park from May-September/October. During April, 20 tups are put on the range. For the first fortnight in April, the tups are fed oats in the morning. Ewes are not given any supplementary feed. Late in the season, about 60 lambs (6 months old) are also put on the range for two weeks. Precise timing for the start or the end of sheep grazing on the range depends on the vegetation growth and is decided by the farm manager. The sheep are removed after September/October.

45 cows (Hereford x Fresian) with calves of the previous year are brought in by the end of April, and kept until the end of August. At the time of the fallow fawning, the cattle are removed from the range for two weeks. 80 cows in late pregnancy are put on the range for calving in the 3rd week of September. In October 1983, the area down the road was separated from the main park by erecting an electric fence, to be an enclosure for the cattle. The cows after calving were transferred to the main park area. The deer, were however, not restricted by the fence, as they could jump over it. Hay cut from adjoining fields is left in the open from the middle of October, to be

made use of both by the cattle and deer. Hay is provided until the 3rd week of November, when the cattle are taken away from the range.

Two salt licks have been provided on the range which are used by the deer as well as the livestock.

3 HABITAT UTILIZATION

3. HABITAT UTILIZATION

3.1 INTRODUCTION

In this section I will examine the patterns of habitat utilization of the three species within the park. Fallow deer were present throughout the year but cattle and sheep only from April to November. Details will be presented for each species throughout the period it was on the range and comparisons will be made for the periods when the species shared the range.

The specific questions asked were:

i. Are the species selective in their choice of habitat within the range ?

ii. Do the species differ in their selection of habitat ?

3.2 METHODS

3.2.1 Distribution of Animals

The nature of the study area was such that the animals could be observed easily without disturbing them. Thus precise information on distribution could be obtained by direct observation. Clearly this was feasible only during daylight hours. Information during darkness could have been obtained by radio-telemetry but this was not permitted in the study area. A suitable image intensifier was also not available. The presence of trees, shrub growth in parts of the range and the boundary wall also made it difficult to observe the herbivores even on clear moonlit nights. The data, therefore, refer only to habitat selection during daytime.

Data on distribution were collected for the daylight hours of a 24-hour period once each week throughout the year. The positions of

all the animals in the study area were plotted once every hour. During winter observations were made on the same day starting from dawn to dusk. Observations during other times of the year were made for a 24-hour cycle starting at 11.00 or 12.00 hours and ending at the same time next day. Maximum number of hours of observation, 20, were made during the months of June and July when it was possible to see the animals as early as 03.00 hours and as late as 23.00 hours, and the minimum, 9, during December when the animals could only be observed from 08.00 hours to 17.00 hours. No records were taken if the animals were disturbed or they were moving from one habitat to another.

Simultaneously, the activity of the animals was also recorded. I recorded only two behavioural patterns i.e. grazing or resting. 'Grazing' was when the animal was eating forage in the field, whether grazing on swards, or browsing on the shrubs and trees. All activities other than grazing e.g., sitting, bedding, lying, standing, urinating, defaecating, or engaged in social acts, were recorded as 'resting'. This is in line with the procedures adopted by Tribe (1949), Colquhoun (1971), Grubb and Jewell (1974), and Osborne (1984).

All records in the field were made on the grid map shown in Fig. 3.1 using different colours for different kinds of animals and different symbols for the activity of animals. Weather parameters i.e., temperature (°C), wind speed, wind direction and cloud cover (%) were also recorded on the same data sheet. Other factors noted were: presence of snow or frost on the ground, rain, showers or snowfall.

3.2.2 Vegetation Analysis

Vegetation analysis was undertaken to identify and describe the major plant communities within the park. An exhaustive analysis of vegetation would have involved too great a time expenditure and, therefore, a system was developed to give an acceptable level of precision for the purpose of this study. The method used was a

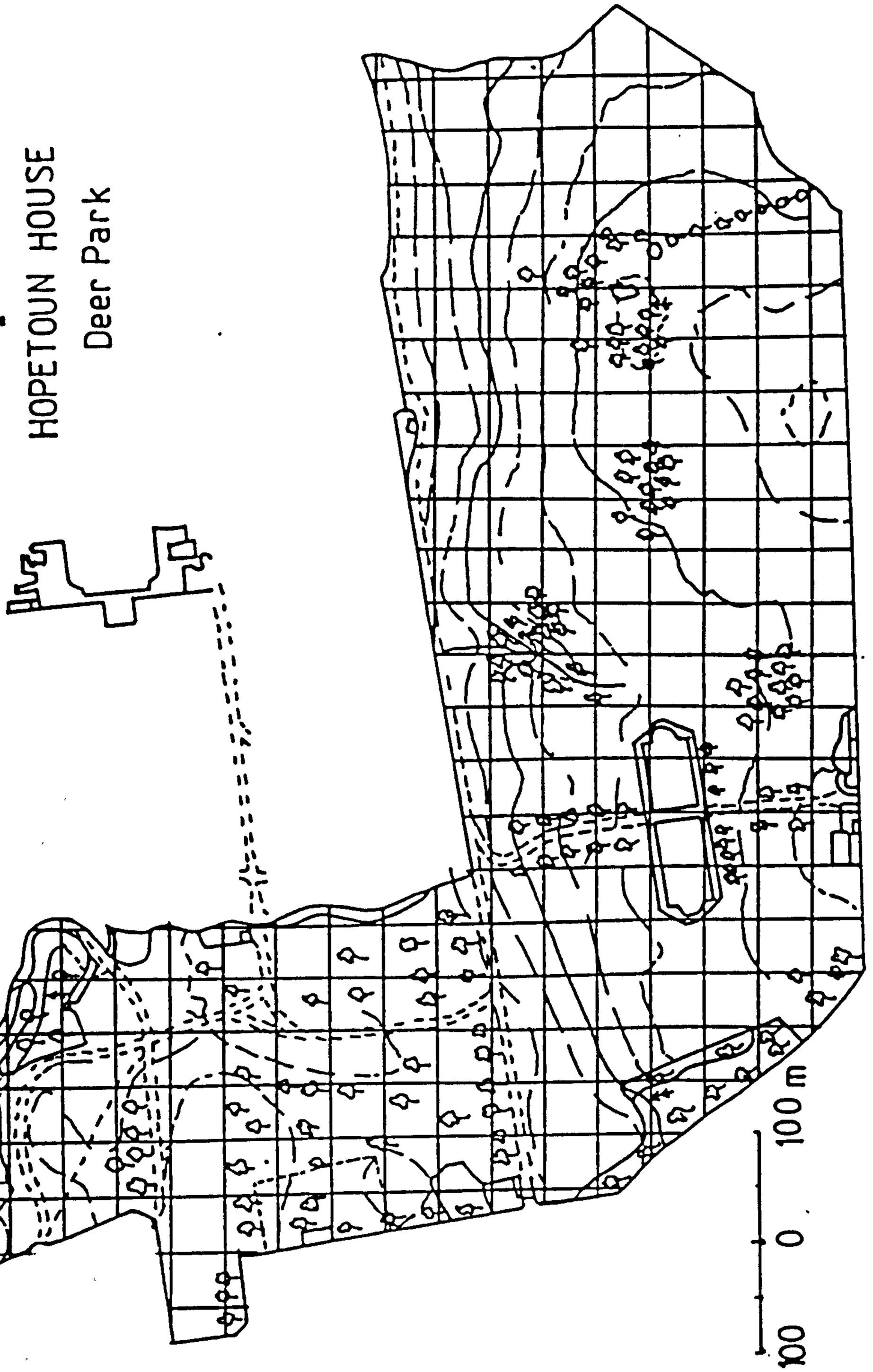


FIG. 3.1 Grid map of Hopetoun House used for recording the distribution of herbivores.

modification of that used by Dunbar (1978), to analyse vegetation in relation to animal distribution in Ethiopia. Dunbar (1978) based his analysis on transects; in this study quadrats were used instead.

The grid map was systematically divided into 32 domains. These had to be of unequal size and shape, because of the irregular boundaries and layout of the park (Fig. 3.2). In each domain, a quadrat of 10 m^2 was laid out, at a random distance from the centre of the domain. Quadrat size in domains with larger number of trees was increased to 15 m^2 to cope with the sparser vegetation there. Two observers walked randomly inside the quadrat, and recorded the plant species at the tip of the toe for each of 250 strides. A pointer was attached to the toe of the boot and at each stride, the plant in contact with the pointer was recorded. For each domain data were, therefore, obtained on the frequency of occurrence of the species within it (Table 3.1). The number of trees in each domain was also recorded. Trees falling on the border between two domains were included in both of them i.e. half the number in each. As the domain size was not equal, the number of trees was converted to numbers per hectare for each quadrat.

Wind speed ratio

As a measure of microtopographic shelter I calculated wind speed ratio between a centrally located open site and all the domains. A Munro Cup Counter Anemometer was erected 1 m above ground level at an open site (the reference site). A modified Sheppard cup anemometer was erected successively along the transect lines passing through the domains (Fig. 3.1 and 3.2), at two locations in each of them. Wind run at 1 m height was recorded, when the wind was blowing from the west, simultaneously at the reference and at each sampling point. Simultaneous sampling was achieved by synchronising the time of the run at each location. Ratio was calculated for each run between the reference and sampling points, taking the value at reference point as one (1). Two ratios recorded in each domain were averaged.

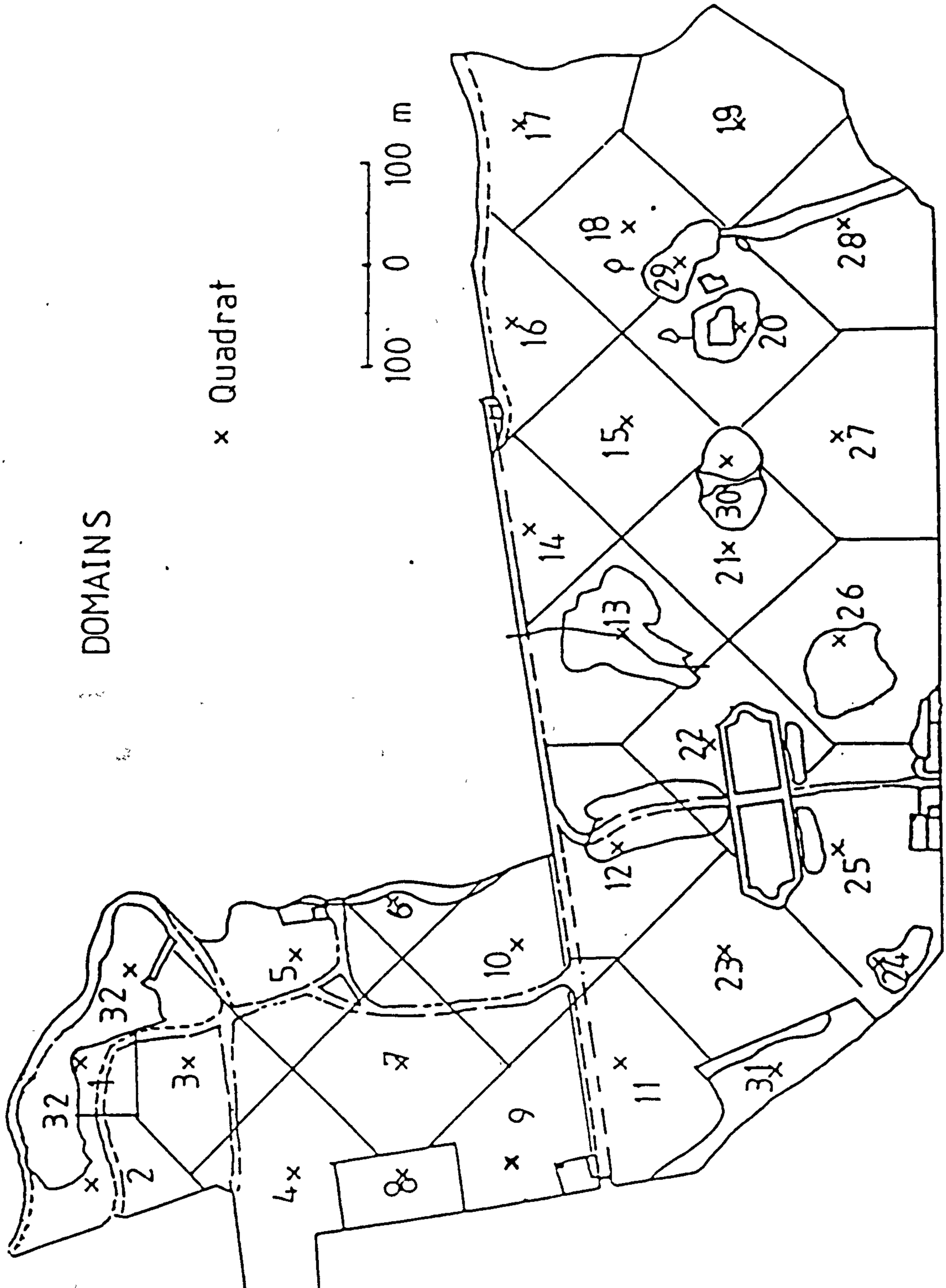


FIG. 3.2 Division of parkland into vegetation domains.

Table 3.1 Botanical composition, percent, of vegetation identified in quadrats, one in each domain.

Plant species *	Domains 1	2	3	4	5	6	7	8
Number of trees/ha	25	18	11	10	11	4	15	4
Agrostis stolonifera	0	0	1.6	0.4	0.4	0	5.6	3.6
Agrostis tenuis	5.2	16.0	8.0	3.6	3.2	6.0	9.6	27.2
Alopecurus pratensis	0	0.4	0	0	0.8	0.4	5.2	4.0
Anthoxanthum odoratum	0.8	0.4	1.6	1.2	0.8	0.4	0.8	1.2
Arrhenatherum elatius	0	1.2	0	0	0	0	0	0
Cynosurus cristatus	7.6	2.4	7.2	20.4	16.4	14.4	10.0	2.4
Dactylis glomerata	2.0	6.8	5.6	5.6	5.6	8.8	14.0	8.0
Deschampsia cespitosa	0	0	0	0	0	0	0	0
Festuca ovina	0	0.8	0	0	0	0	0	0
Festuca rubra	7.2	16.8	6.8	10.0	6.8	5.6	4.0	6.0
Holcus lanatus	3.2	9.2	6.4	4.8	11.6	3.2	16.0	0.4
Holcus mollis	0	1.2	0	0	0	0	0	0
Lolium perenne	34.0	11.6	37.2	30.4	28.4	27.2	21.2	28.0
Phleum pratense	0.4	2.4	1.6	1.6	1.6	2.4	1.2	2.0
Poa annua	0	0	0	0	0	0.4	0	0
Poa pratensis	0.4	0	0	0	1.2	0	0	0.4
Poa trivialis	0	0	0	1.6	0	0.4	0.8	0
Carex	0	0	0	0	0	0	0	0
Juncus effusus	0	0	0	0	0	0	0	0
Luzula campestris	4.4	3.6	0	0	1.6	0.4	0	0
Grasses and rushes	65.2	72.8	76.0	79.6	78.4	69.6	88.4	83.2
Achillea millefolium	0.4	0.4	0.4	0	0	0	0	0.4
Cerastium fontanum	3.6	5.6	1.2	0.4	3.2	4.0	0.4	1.2
Cirsium vulgare	0	0	0	0	0	0	0.4	0
Digitalis purpurea	0	0	0	0	0	0	0	0
Galium aperine	0	0	0	0.4	0	0	0	0
Leontodon autumnalis	0	0	0	0	0.4	6.4	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0
Plantago lanceolata	0.4	0	0	0.4	0	4.8	0.4	0
Prunella vulgaris	2.8	0.4	0	0	0.4	0	0	0
Ranunculus acris	0	0.8	0	0	0	0	0	0
Ranunculus repens	7.6	5.2	4.0	0	0.4	0.4	2.4	0
Rumex acetosa	0	4.4	3.2	0.8	2.4	0.4	0.4	0
Rumex acetosella	0	0.4	0.8	0.4	0	2.4	0	0
Stellaria media	0	0.4	0	0	0	0	0	0
Taraxacum officinale	0	0	0	0	0	0	0	0
Trifolium repens	18.8	7.6	14.4	16.4	14.8	8.8	6.4	15.2
Urtica dioica	0	0	0	1.6	0	2.4	0.4	0
Veronica chamaedrys	0.4	2.0	0	0	0	0.8	0.8	0
Total forbs	34.0	27.2	24.0	20.4	21.6	30.4	11.6	16.8
Moss	0.8	0	0	0	0	0	0	0
Litter	0	0	0	0	0	0	0	0
Blank	0	0	0	0	0	0	0	0

* Nomenclature follows Martin (1972).

Table 3.1 Botanical composition, percent, of vegetation identified in quadrets, one in each domain. (continued)

Plant species	Domains 9	10	11	12	13	14	15	16
Number of trees/ha	12	13	9	6	22	0	2	0
Agropyron repense	0	0	0	0.4	0	0	0	0
Agrostis stolonifera	2.0	4.4	0.0	0.8	8.0	0	0	0.4
Agrostis tenuis	6.4	17.2	10.8	10.8	31.2	10.4	4.8	8.8
Alopecurus pratensis	0	1.6	0.4	0	0	0	0	0.4
Anthoxanthum odoratum	0.4	5.6	1.6	0	2.4	6.4	4.8	2.4
Arrhenatherum elatius	0	0	1.2	0	0	0	1.2	0
Cynosurus cristatus	13.6	20.0	13.6	17.2	2.4	10.4	22.0	8.8
Dactylis glomerata	6.8	5.2	7.6	10.0	17.6	4.0	4.4	15.2
Deschampsia cespitosa	0	0	0	0	0	0	0	0
Festuca ovina	0	0	0	0	0	0	0	0
Festuca rubra	7.6	3.2	8.4	2.4	0.8	6.4	8.8	8.8
Holcus lanatus	7.2	2.4	4.8	2.4	17.2	6.0	6.4	7.2
Holcus mollis	0	0	0	0	0	0	0	0
Lolium perenne	43.6	24.4	30.4	37.2	16.0	17.2	31.2	36.0
Phleum pratense	0.8	1.6	0.8	1.2	0	0	0	2.0
Poa annua	0	0	0	0	0	0	0	0
Poa pratensis	0	0.8	0	0.4	0	0	0	0
Poa trivialis	0	0	0	0	0.8	0	0	2.0
Carex	0	0	0	0	0	4.0	0	0.8
Juncus effusus	0	0	0	0	0	0	0	0
Luzula campestris	0	0	0.4	0	0	6.0	3.2	0.4
Grasses and rushes	88.4	88.0	80.0	82.8	97.2	70.8	86.8	93.2
Achillea millefolium	0	0	0	0	0	1.6	0	0
Cerastium fontanum	0.8	0.4	1.2	2.0	0.8	0	1.6	1.2
Cirsium vulgare	0	0	11.2	0	0	0	3.6	2.4
Digitalis purpurea	0	0	0	0	0	0	0	0
Galium aperine	0	0	0	0	0	0	0	0
Leontodon autumnalis	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	1.6	0	0
Plantago lanceolata	1.6	0	0	0	0	22.0	0.4	0.4
Prunella vulgaris	1.2	0	0.4	0	0	0.4	0	0
Ranunculus acris	0	0.4	0	0	0	0.8	0	0
Ranunculus repens	1.2	0.8	0	2.4	1.6	0.4	0	0.4
Rumex acetosa	0	0	0	0	0	0	0	0
Rumex acetosella	0	0	0	0	0	0.4	0	0.8
Stellaria media	0	0	0	0	1.2	0	0	0
Taraxacum officinale	0.4	0	0	0	0	0	0	0
Trifolium repens	6.4	12.0	7.2	12.8	0	2.0	7.6	1.2
Urtica dioica	0	0	0	0	0	0	0	0
Veronica chamaedrys	0	0	0	0	0	0	0	0
Total forbs	11.6	13.6	20.0	17.2	3.6	29.2	13.2	6.4
Moss	0	0	0	0	0	0	0	0.4
Litter	0	0	0	0	0	0	0	0
Blank	0	0	0	0	0	0	0	0

Table 3.1 Botanical composition, percent, of vegetation identified in quadrats, one in each domain. (continued)

Plant species	Domains 17	18	19	20	21	22	23	24
Number of trees/ha	0	5	5	18	5	7	5	36
Agrostis stolonifera	0	0	0	11.2	0	0.4	0	20.0
Agrostis tenuis	6.0	6.4	5.6	16.8	13.2	8.0	10.4	31.2
Alopecurus pratensis	0	0	0	0	0	0	0	0.4
Anthoxanthum odoratum	3.6	2.8	3.6	0	0.4	2.0	0	0
Arrhenatherum elatius	2.0	0.8	0.4	0	0.4	0	0	0
Cynosurus cristatus	8.0	7.6	9.2	1.2	14.0	18.8	9.6	0
Dactylis glomerata	8.4	4.8	9.6	7.6	4.0	2.8	2.8	8.8
Deschampsia cespitosa	0.8	0	0	0	0	0	0	0
Festuca ovina	0.4	0.8	0.4	0	0.4	0.4	0	2.0
Festuca rubra	10.0	14.4	11.6	1.2	1.2	1.6	3.6	0
Holcus lanatus	5.6	3.2	1.6	2.4	5.6	0.4	8.0	0.8
Holcus mollis	0	0	0	0	0	0	0	0
Lolium perenne	32.0	24.0	39.2	54.0	46.0	44.0	48.0	13.6
Phleum pratense	0	0	0	0	1.6	1.2	2.0	0
Poa annua	0	0	0	0	0	0	0	1.6
Poa pratensis	0	0	0.4	0.4	0	0	0	0
Poa trivialis	0	0	0	1.6	0	0	0	9.6
Carex	0	3.6	0	0	0	0	0	0
Juncus effusus	0	0	0	0	0	0	0	0
Luzula campestris	3.2	1.6	0.8	0	0	0.8	0	0
Grasses and rushes	80.0	70.0	82.4	96.4	86.8	80.4	84.4	88.0
Achillea millefolium	0	1.6	0	0	0	1.6	0	0
Bellis perennis	0	0	0	0	0	0.8	0	0
Cerastium fontanum	2.4	0	0.8	0	0.8	0.4	1.6	0
Cirsium vulgare	0	0	7.6	0	2.0	2.0	0	6.0
Digitalis purpurea	0	0	0	0	0	0	0	0
Galium aperine	0	0	0	0	0	0	0	0
Leontodon autumnalis	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0
Plantago lanceolata	7.6	19.6	0	0	0	0.4	0	0
Prunella vulgaris	0	0	0	0	0	0.8	0	0
Ranunculus acris	0	0	0	0	0	0	0	0
Ranunculus repens	0	0	0	0	0.8	0.4	2.4	0.4
Rumex acetosa	0	0	0	0	0	0	0	0
Rumex acetosella	2.4	0	0	0	0	0	0	0
Stellaria media	0	0.4	1.6	0	0	0	0	0.8
Taraxacum officinale	0	0	0	0	0	0	0	0
Trifolium repens	6.8	7.6	5.6	0	9.6	13.2	11.6	0
Urtica dioica	0	0	0	0	0	0	0	2.4
Veronica chamaedrys	0	0.8	0	3.6	0	0	0	0
Total forbs	19.2	30.0	15.6	3.6	13.2	19.6	15.6	9.6
Moss	0.8	0	2.0	0	0	0	0	1.2
Litter	0	0	0	0	0	0	0	0.4
Blank	0	0	0	0	0	0	0	0.8

Table 3.1 Botanical composition, percent, of vegetation identified in quadrats, one in each domain. (continued)

Plant species	Domains 25	26	27	28	29	30	31	32
Number of trees/ha	10	8	1	6	33	30	49	98
Agrostis stolonifera	0	10.4	0	0	18.8	10.4	29.2	1.2
Agrostis tenuis	10.0	16.0	3.6	18.0	8.0	10.8	26.4	13.6
Alopecurus pratensis	0	0	0	0	0.4	0	0	0
Anthoxanthum odoratum	4.8	0	0.4	5.2	0	0	0	1.2
Arrhenatherum elatius	0.4	0	0.4	0	0	0	0	1.6
Cynosurus cristatus	11.6	4.8	21.6	18.4	0.8	0	0	0
Dactylis glomerata	0	11.6	0.4	2.4	11.6	8.0	5.2	0
Deschampsia cespitosa	0	0	3.6	0	0	0	0	0
Festuca ovina	2.8	0.4	0.8	0.4	0	0	0	0
Festuca rubra	12.8	0.4	0.8	6.8	0.8	0	0.4	0.4
Holcus lanatus	4.4	0.8	4.0	7.6	2.8	0	0.8	22.0
Holcus mollis	0	0	0	0	0	0	0	5.2
Lolium perenne	41.2	36.8	51.6	33.2	20.4	39.6	12.8	0.8
Phleum pratense	0	0.8	0	0	0	0	0	0.4
Poa annua	0	0	0.4	0	0	5.2	0	0
Poa pratensis	0	0.8	1.2	0	0.4	0.4	0.4	0
Poa trivialis	0	0.4	0	0	6.0	3.2	7.6	0
Carex	0	0	0	0	0	0	0	0
Juncus effusus	0	0	0	0	0	0	0	2.8
Luzula campestris	1.2	0	0.4	0.8	0	0	0	0
Grasses and rushes	89.2	83.6	89.6	92.8	70.0	77.6	82.8	49.2
Achillea millefolium	0	0	0	0	0	0	0	0.4
Cerastium fontanum	0	1.2	1.2	0.8	0.8	0	0	0
Cirsium vulgare	0	0	0.4	2.4	0	0	0	1.2
Digitalis purpurea	0	0	0	0	0	0	0.8	3.2
Galium aperine	0	0	0	0	0	0	0	4.4
Galium verum	0	0	0	0	0	0	0	1.2
Leontodon autumnalis	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0
Plantago lanceolata	0	0	0	0	0	0	0	0
Prunella vulgaris	0	0	0	0	0	0	0	0
Ranunculus acris	0	0	0	0	0	0	0	0
Ranunculus repens	0	4.8	0	0	0.4	0.8	0	1.2
Rumex acetosa	0	0	0	0	0	0	0	0
Rumex acetosella	0	0	0	0	0	0	0	0
Stellaria media	0	6.4	0	0	0.8	7.2	0	0.4
Taraxacum officinale	0	0	0	0	0	0	0	0
Trifolium repens	10.4	4.0	9.2	2.4	1.2	0.8	0	0
Urtica dioica	0	0	0	0	15.6	3.2	0	4.8
Veronica chamaedrys	0	0.4	0	0.8	1.6	0	6.0	2.8
Total forbs	10.4	16.8	10.8	6.4	20.4	12.2	6.8	19.6
Rubus spp.	0	0	0	0	0	0	0	9.6
Moss	0	0	0	1.2	0	1.6	0	0
Pteridium sp.	0	0	0	0	0	0	0	3.6
Litter	0.4	0	0	0	0	1.6	6.4	4.8
Blank	0	0	0	0	9.6	8.0	4.0	13.2

3.3 RESULTS

3.3.1 Analysis of Vegetation

The objective was to identify the different plant associations within the study area, and to find out their relationship with the distribution of animals both on a community level and on a broader level of habitat types. Different plant associations could be considered as habitats available for the animals to select for feeding. The number of vegetation variables was large and I, therefore, decided to use Principal Component Analysis (PCA) to explore the interdependence among the variables. Gittins (1965a, 1965b, 1969) used this technique to analyse grass communities in Anglesey, N. Wales; Bray and Curtis (1957) to study the upland forest communities of southern Wisconsin, U.S.A., and Austin (1968) to study chalk grassland community in Kent, England.

I used PCA to find out the inter-relationship of plant species by manipulating the matrix of estimates of their abundance (frequency of occurrence, Table 3.1). Ordination both for species and stands was achieved using Genstat (General Statistics) Computer Package.

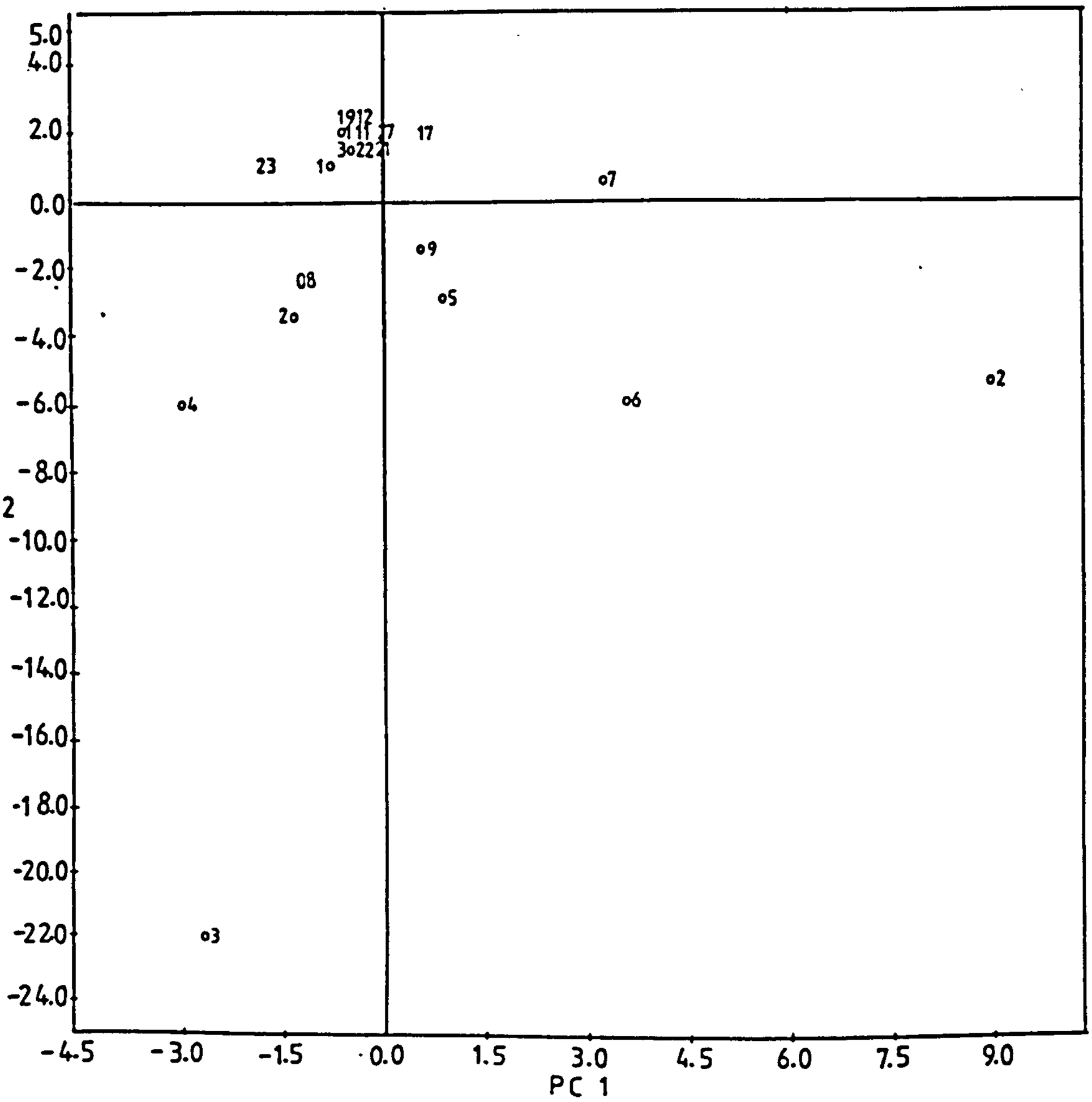
Species ordination

Of the 43 species occurring on the range, 31 were used for ordination, omitting the very rare species. As a measure of macro and micro topographical shelter, affecting the vegetation, number of trees and wind speed ratios were also included, with the variables. The resulting principal component scores for the first 5 principal components are given in Table 3.2 which also shows the variation explained by the principal components. The table is similar to a data matrix. The columns in a data matrix relate to actual stands, showing the frequency of each species present, whereas a correspondence has been set up, in this case, between the columns and the co-ordinate axes, to represent each stand by an axis. The columns in Table 3.2

Table 3.2 Principal component scores for stand ordination.

Variable	No.	Principal component 1	2	3	4	5
Wind speed ratio	1	1.9507	-0.4754	-0.2944	0.1908	0.0412
Number of trees	2	-5.5446	8.9633	-0.5205	-2.6494	1.0944
Lolium perenne	3	-22.1572	-2.7851	-1.6669	1.2133	1.2178
Cyno. cristatus	4	-5.9842	-3.1310	0.1513	-1.9610	-1.1983
Dact. glomerata	5	-2.8433	0.9302	0.8519	1.2007	-0.8336
Agros. tenuis	6	-5.8591	3.6417	2.6646	2.6768	-2.1904
A. stolonifera	7	0.4427	3.3218	-0.8789	1.8143	0.6842
Festuca rubra	8	-2.2514	-1.2966	2.1896	-1.6073	-0.0756
Holcus lanatus	9	-1.5414	0.5407	1.4523	-1.1554	-1.2642
Anthox. odoratum	10	1.0988	-0.8921	0.5932	0.0394	0.1115
Alop. pratensis	11	2.1951	-0.2782	-0.2793	0.1719	-0.4534
Arrhen. elatius	12	2.3625	-0.4188	-0.3050	0.0723	-0.0390
Phleum pratense	13	1.8201	-0.4772	-0.3909	0.0107	-0.3976
Luzula campestris	14	1.7719	-0.6146	0.5522	-0.2944	0.3999
Poa annua	15	2.4151	-0.2208	-0.5566	0.2591	0.1348
Poa pratensis	16	2.4316	-0.4365	-0.4783	0.1379	-0.0742
Poa trivialis	17	2.0082	0.6949	-0.5878	0.4884	0.2716
Festuca ovina	18	2.3636	-0.3552	-0.3308	0.1072	0.0208
Des. cespitosa	19	2.4265	-0.5149	-0.5020	0.1713	0.0168
Trifol.repens	20	-3.7153	-1.5136	-0.2187	-2.0966	-1.0800
Ranun.repens	21	1.7106	-0.0341	-0.1844	-0.1340	-0.0660
Cerast. fontanum	22	1.6792	-0.4153	-0.3292	-0.2132	-0.3392
Pl. lanceolata	23	0.9604	-1.6854	3.7113	0.1869	3.1925
Prun. vulgaris	24	2.4179	-0.4124	-0.5278	0.0245	0.0359
Rum. acetosella	25	2.2590	-0.3051	-0.2609	-0.1979	-0.2525
Rum. acetosa	26	2.3455	-0.5331	-0.3946	0.1778	0.0103
Stell.media	27	2.1251	-0.1032	-0.7227	0.5917	0.2648
Ach.millefolium	28	2.3860	-0.5391	-0.1113	0.1450	0.2684
Ver.chamaedrys	29	2.1991	0.0566	-0.3195	0.0909	0.1292
Cersium vulgare	30	1.5868	-0.4815	-0.5171	0.2620	-0.3491
Urtica dioica	31	2.0662	0.4859	-0.8560	0.0277	0.6569
Moss	32	2.3493	-0.3833	-0.4886	0.1917	0.0601
Pteridium sp.	33	2.5245	-0.3329	-0.4443	0.0567	0.0023
Variance (%) explained		71.0266	13.1749	3.6549	2.4002	1.6273

Plant species names as in Table 3.1.



POINTS COINCIDING WITH POINT 01
13 14

POINTS COINCIDING WITH POINT 12
15 16 18 24 25 32 33

POINTS COINCIDING WITH POINT 19
26 28

POINTS COINCIDING WITH POINT 27
29

POINTS COINCIDING WITH POINT 17
31

FIG. 3.3 Species ordination:Principal Component 1 scores plotted against Principal Component 2 scores.

Table 3.3 Kendall's rank correlation co-efficients (τ)£ between plant species, (significant only).

Plant species	1	2	3	4	5	6	7	8	9	10	13	12	13
1. Wind speed Ratio													
2. Trees(number)	-*												
3. L. perenne													
4. F. rubra													
5. A. tenuis		*		-**									
6. H. lanatus													
7. C. cristatus		-*			-*								
8. Ph. pratense	-*												
9. D. glomerata													
10.Poa spp.				**		-*							
11.Anth.odoratum		-*		**			*			-*			
12.R. repens													
13.T. repens				-**			*	**		-*			
$													
14.Cer. fontanum							*	*		-*			
$													
15.Pl. lanceolata		-*		*		-**							*

£ Kendall's rank correlation co-efficients calculated using BMDP Computer Package (Dixon *et al.* 1983).
* Significant at 0.05 level
** Significant at 0.01 level
\- Negative correlation
$ No significant correlation with each other

define the rotated co-ordinate axes of the sample space. The column entries represent the location of species with respect to these axes.

The position of species has been plotted in relation to PC 1 and PC 2 in Fig. 3.3, both of which together explain more than 84 % of variance between them. The plotting suggests that some of the species are positioned close to one another, whereas some of them are farther apart. Greater ecological similarity is represented by the points which are closely positioned and vice-versa. Variables (species) that stand out from the main group and which, therefore, contribute substantially to the pattern of variation are : Number of trees (2), *Agrostis stolonifera* (7), *Agrostis tenuis* (6), *Anthoxanthum odoratum* (10), *Cynosurus cristatus*(4), *Dactylis glomerata* (5), *Festuca rubra* (8), *Holcus lanatus* (9), *Lolium perenne* (3), *Phleum pratense* (13), *Poa trivialis* (17), *Trifolium repens* (20), *Ranunculus repens* (21), *Cerastium fontanum* (22), and *Plantago lanceolata* (23).

I calculated Kendall's rank correlation co-efficients (Table 3.3) to determine the significance of correlation between the variables. Least correlations were shown by *Lolium perenne* with other variables. Important significant correlations were shown between the 'number of trees' and *Agrostis* spp., and significant negative correlations between number of trees and *Cynosurus cristatus*, *Anthoxanthum odoratum* and *Plantago lanceolata*. *Agrostis* spp. were negatively correlated with *Festuca rubra*, *Trifolium repens* and *Plantago lanceolata*.

Stand ordination

The 32 stands (domains) were ordinated using the abundance of 31 species, the number of trees, and the wind speed ratio for each domain. Principal Component Scores for the first 5 principal components are shown in Table 3.4. Rows in the Table represent the co-ordinates of each stand on the principal components. Stand positions are plotted against the first two principal component axes (Fig. 3.4). The stand positions follow the same principle as explained for the species positions i.e., the closer

Table 3.4 Principal component scores for stand ordination.

Trees number	Wind ratio	Variable No.	Principal component 1	2	3	4	5
25	0.36	1	-4.0050	6.1094	-3.0938	4.0358	-1.7558
18	0.18	2	-1.3754	4.7207	1.6216	0.6438	2.5147
11	0.46	3	-1.5303	1.8710	-0.2682	-0.8437	1.2460
10	0.65	4	-1.4278	0.1366	-0.2499	-1.5361	0.0025
11	0.61	5	-2.2568	2.2409	-0.2669	-1.2957	0.1385
4	0.66	6	-1.3637	0.9649	-0.3626	-1.3978	1.7293
15	0.86	7	0.8723	0.4258	0.4215	-2.1572	1.8022
4	0.68	8	0.0420	0.5312	-0.9102	-1.5798	1.4990
12	0.63	9	-0.8996	0.2431	-0.5207	-0.7274	-0.6486
13	0.65	10	-0.9676	-0.1449	-0.3993	-0.9900	-0.1373
9	0.70	11	-0.6303	-0.7619	0.6668	-1.0988	-0.8026
6	1.13	12	-1.0231	-0.3151	-1.4134	-1.3728	-0.0961
22	0.76	13	2.7495	-0.3156	0.8027	-1.1982	1.6856
0	1.18	14	-2.3464	-2.0224	2.8623	4.2779	1.9137
2	1.05	15	-2.1953	-1.6619	1.3263	-0.2602	-0.6251
0	0.77	16	-0.2783	-0.6230	0.9465	-1.2919	0.8783
0	1.25	17	-1.7820	-2.6842	0.7710	1.0846	1.3693
5	0.87	18	-1.6568	-1.8580	2.9275	2.7954	0.9799
5	0.66	19	-0.6489	-2.0097	-0.6178	0.7652	-0.6014
18	0.77	20	2.5740	-0.7145	-0.7463	-0.5064	-0.2245
5	0.72	21	-0.6889	-0.3224	-0.5747	-1.6512	-1.1534
7	0.87	22	-2.0699	-0.9209	-0.4009	0.7637	-1.1661
5	0.74	23	-1.0896	0.3475	-0.8333	-1.7156	-0.8017
36	0.41	24	5.4521	-0.5005	-1.5159	1.7277	0.6523
10	1.09	25	-1.5626	-2.5016	1.0010	0.5199	-0.9646
8	0.74	26	1.4403	0.5799	-2.5982	0.5430	0.3770
1	0.86	27	-1.5839	-2.0501	-1.2181	-1.1233	-3.5966
6	0.91	28	-0.4472	-1.8762	0.6910	0.0314	-0.6265
33	0.77	29	4.4339	0.3196	-0.5059	0.0431	0.7564
30	0.85	30	3.9347	-1.8314	-3.9951	2.8866	-0.9457
49	0.42	31	5.8696	1.1076	0.1338	0.5722	0.6350
98	0.17	32	4.4608	3.5161	6.3191	0.0559	-4.0337
	Variance (%) explained		19.2116	12.2715	10.4962	8.4255	6.6245

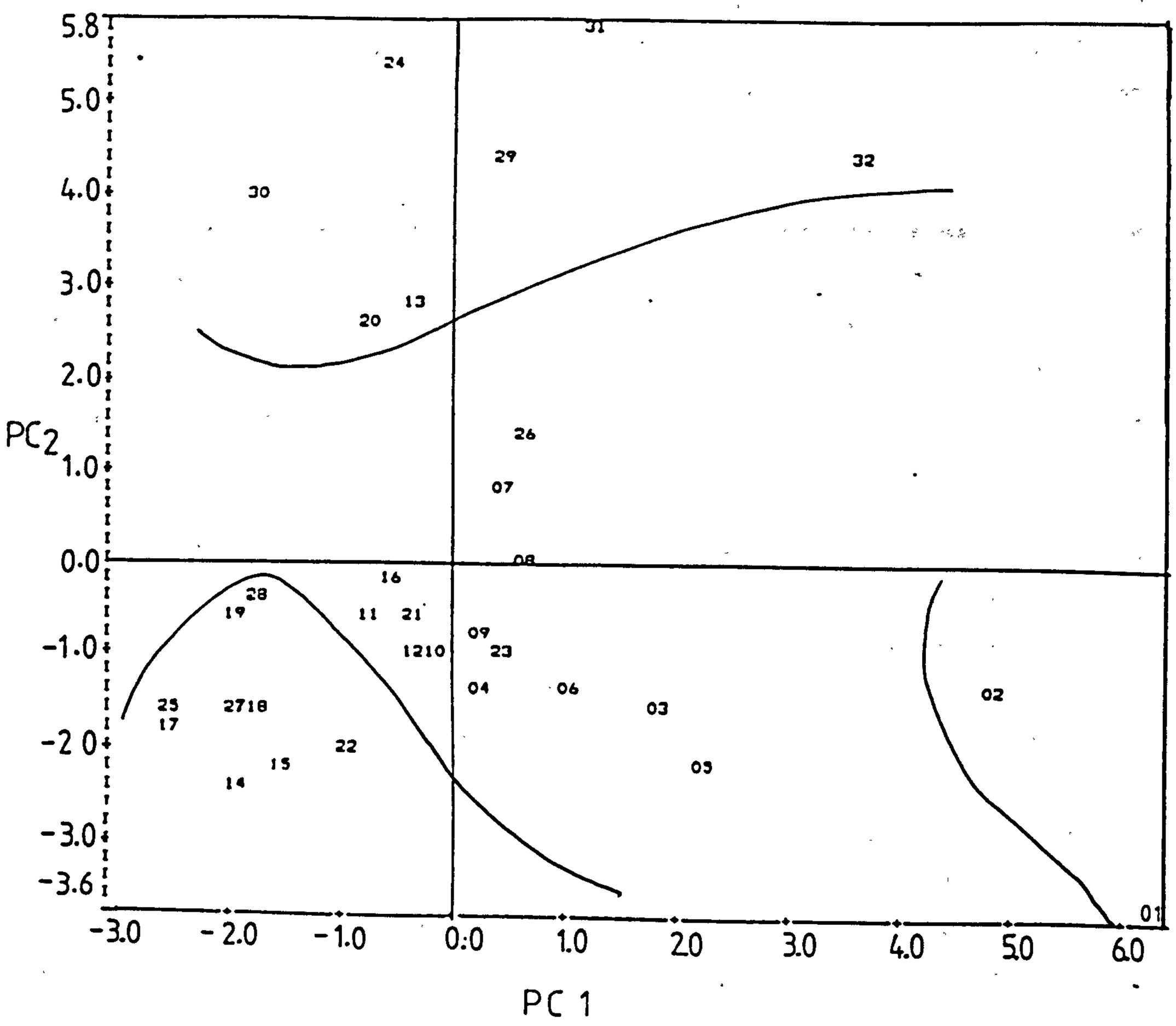


FIG. 3.4 Stand Ordination:Principal Component 1 scores plotted against Principal Component 2 scores.

the position, the greater the similarity and *vice- versa*. The variation explained by the two principal components is rather small (32 %) and can be explained on the basis of existing conditions in the area.

The ecological significance of such a reference frame needs some considerations. As Gittins (1969) has pointed out, "Identification of the ecological factors involved is a matter for interpretation, and as such, it is dependent in part on the judgement of the investigator. Usually it involves an attempt to evaluate the results of the ordination against information external to the analysis".

The first two principal components can be associated with the number of trees (a positive relationship with PC 1) and wind speed ratio (a negative relationship with PC 2 - Fig. 3.5.a and 3.5.b), in being most effective on the ordination of stands. The ordination (Fig. 3.4) shows 4 distinct groups (Table 3.5). The inclusion of domains 12 (higher wind speed ratio) and 16 (without any trees) in shaded areas, and that of domain 25 (with a higher number of trees for the type) in grassland areas can be explained on the basis of the knowledge of the area, and the possible interaction of number of trees and wind speed ratios. Domain 12 had a higher wind speed ratio because of a sudden change in height (elevation) of ground level (Fig. 2.1). Domain 16, though does not have trees, but the wind speed ratio is consonant with the ratios in other domains of the type, which could be the cumulative effect of the conditions in the surrounding domains. Domain 25 has a higher number of trees (for the type) but also has a higher wind speed ratio which justified its inclusion in grassland areas.

Habitat type (1) included only two domains which in terms of tree numbers and low wind speed ratio (as an effect of the presence of trees) seems to be closely related to domains in habitat type (2), though located at a distance in ordination (Fig. 3.4). Therefore, I amalgamated the two habitats into one. The extent of the area for the

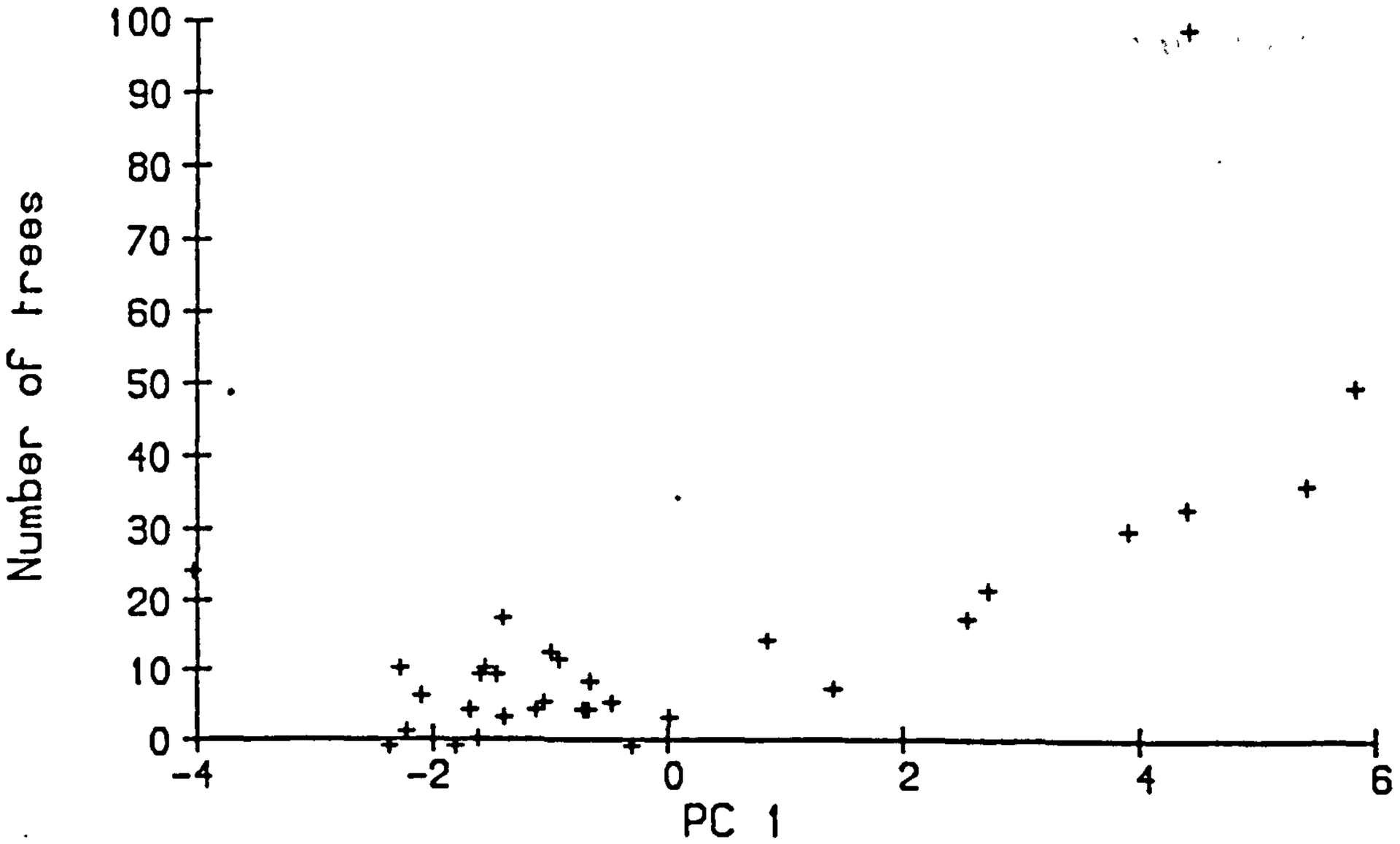


Fig. 3.5.a PC 1 in relation to number of trees

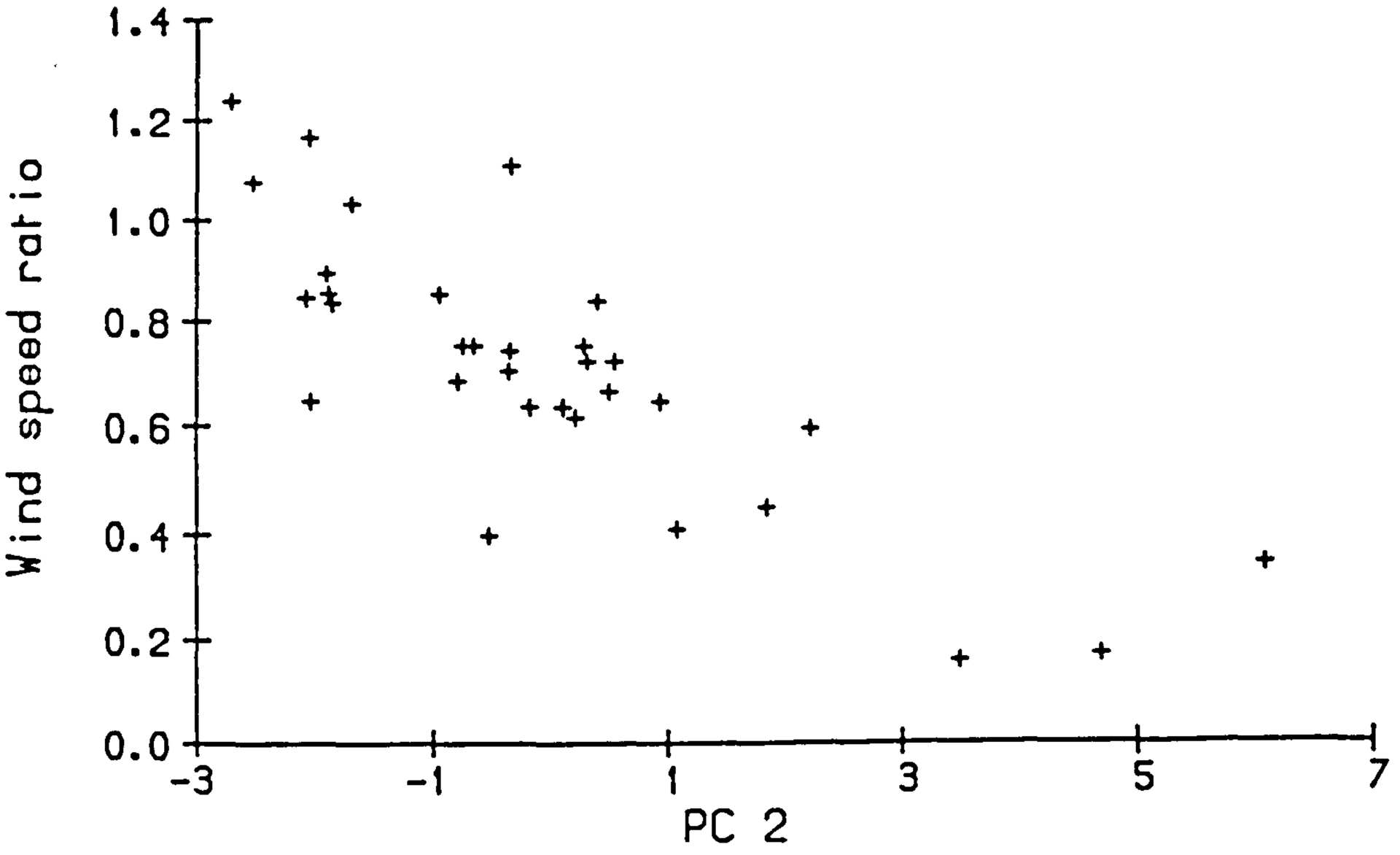


Fig. 3.5.b PC 2 in relation to wind speed ratio

Table 3.5 Grouping of domains into general habitat types.

Habitat type	Domains (No.)	Trees number	Wind speed ratio
1. Areas shaded by trees	1	25	0.36
	2	18	0.18
2. Tree groves	13	22	0.76
	20	18	0.77
	24	36	0.41
	29	33	0.77
	30	30	0.85
	31	49	0.42
	32	98	0.17
3. (Partially) Shaded areas	3	11	0.46
	4	10	0.65
	5	11	0.61
	6	4	0.66
	7	15	0.86
	8	4	0.68
	9	12	0.63
	10	13	0.65
	11	9	0.70
	12	6	1.13*
	16	0*	0.77
	21	5	0.72
	23	5	0.74
	26	8	0.74
4. Grassland areas	14	0	1.18
	15	2	1.05
	17	0	1.25
	18	5	0.87
	19	5	0.66
	22	7	0.87
	25	10*	1.05
	27	1	0.86
	28	6	0.91

* Values explained in the text.

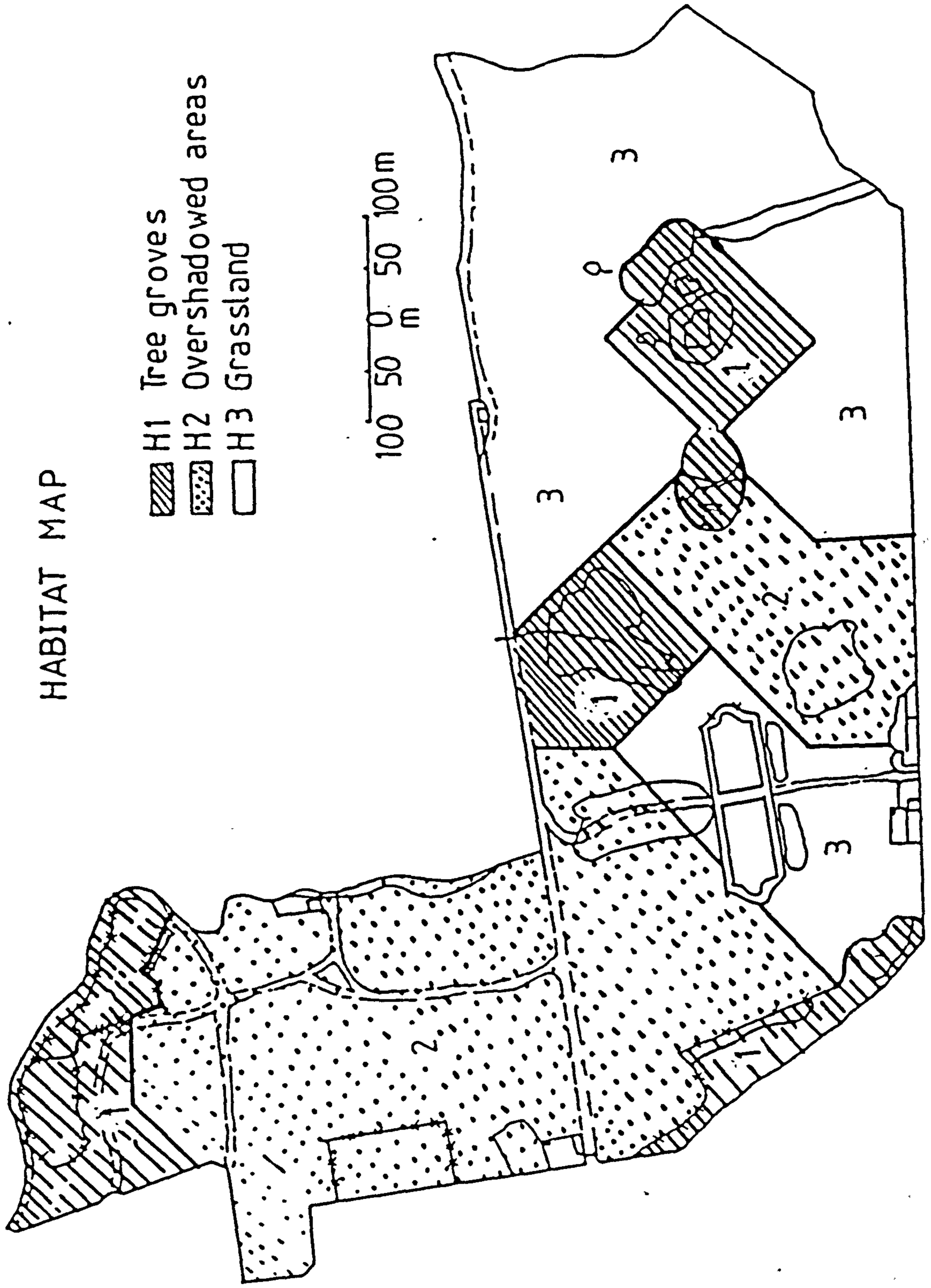


FIG. 3.6 Map showing the distribution of broad categories of habitat.

3 habitats was calculated as follows (Fig. 3.6):

		Area (ha)
1.	Tree groves	10.70
2.	(Partially) Shaded areas	26.32
3.	Grassland areas	16.62
	Total area	53.64

3.3.2. Distribution of Animals

3.3.2.a Use of plant species

Number of trees (Table 3.6.1)

Grazing: Of the four types of herbivores only sheep showed a consistent relationship with the presence of trees. For 5 of the 7 months that sheep were on the range they displayed a strong negative association with trees i.e. they avoided the more densely covered areas. Cattle showed no particular association with trees. Both fallow bucks and does were positively associated with trees in October and November but not at other times.

Resting: Neither cattle nor sheep showed any significant association with trees whilst resting, and fallow bucks and does were positively associated with trees only in October, November and May.

Lolium perenne (Table 3.6.2)

Grazing: All the herbivores showed a predominantly positive relationship with the presence of *Lolium* i.e. they fed most often in the areas with the highest density of *Lolium*. Sheep showed the most consistent and highest levels of association with *Lolium*. Fallow bucks showed the lowest level of association - although the rank correlation co-efficients were positive in all but one month, they were statistically significant in only 3 months. For fallow does, the

Table 3.6.1 Kendall's rank correlation co-efficients (τ)£ for the use of domains with trees by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	0.31**	0.45***	0.27*	0.23*	-0.22*	-0.03	-0.44***	-0.32**
November	0.28*	0.26*	0.38**	0.39**	0.01	-0.00	---	---
December	-0.11	0.23	-0.06	0.22	---	---	---	---
January 1983	-0.04	0.14	-0.15	0.17	---	---	---	---
February	0.16	0.26*	0.06	0.14	---	---	---	---
March	0.11	-0.06	0.06	0.01	---	---	---	---
April	0.14	0.16	0.13	0.13	0.00	-0.07	0.16	0.17
May	0.10	0.31**	0.18	0.28*	0.11	-0.01	-0.37**	-0.11
June	-0.03	-0.04	0.18	0.07	0.09	-0.18	-0.21*	-0.08
July	-0.11	-0.16	0.14	0.07	0.04	0.06	-0.25**	0.01
August	-0.03	0.02	-0.01	0.16	-0.01	-0.16	-0.36**	-0.05
September	0.14	0.05	0.20	0.21	---	---	-0.07	0.03

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al.* 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.2 Kendall's rank correlation co-efficients (τ)£ for the use of *Lolium perenne* by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	0.02	0.05	0.22 *	0.20	0.46 ***	0.30 **	0.39 **	0.37 **
November	-0.08	0.16	0.07	-0.01	0.25 *	0.32 **	---	---
December	0.21 *	-0.03	0.17 *	-0.09	---	---	---	---
January 1983	0.22	-0.01	0.23	0.21	---	---	---	---
February	0.02	-0.09	0.12	0.03	---	---	---	---
March	0.21 *	0.34 **	0.26 *	0.29 *	---	---	---	---
April	0.25	0.14	0.23	0.20	0.03	0.05	-0.06	-0.12
May	0.01	-0.22	0.06	0.11	0.07	0.32 **	0.45 ***	0.38 **
June	0.08	-0.04	0.08	0.12	0.11	0.25 *	0.47 ***	0.34 **
July	0.31	0.19	0.33 *	0.35	0.22 *	0.28 **	0.40 ***	0.31 **
August	0.11	0.13	0.29	0.16	0.24	0.37	0.45 *	0.36 **
September	0.06	0.05	0.21	0.07	---	---	0.27	0.31

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al.* 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

co- efficients were positive in all months and significant in 6 of them. Cattle also were positively associated with *Lolium* in all 7 months they were on the range, and significantly so for 4 of them.

Resting: Sheep and cattle were just as strongly associated with *Lolium* during resting as they were during feeding suggesting no movement away from feeding areas to rest. However, both fallow bucks and does showed much less of an association with *Lolium* during resting suggesting perhaps some separation of feeding and resting preferences.

Festuca rubra (Table 3.6.3)

None of the herbivores showed any marked relationships with *Festuca* abundance although there was a general tendency (not statistically significant) for a slight negative relationship especially in fallow does and in sheep.

***Agrostis* spp.** (Table 3.6.4)

Grazing: Fallow bucks and does generally showed a positive relationship with the presence of *Agrostis*. Bucks were significantly positively related to the presence of *Agrostis* in October, November and March, and does in March, June, July and September. Bucks showed a negative (but non- significant) relationship in 3 months and does only in one month. Cattle showed a negative non- significant relationship with the presence of *Agrostis* in 6 months out of 7, and the sheep in 4 months out of 7 months they were on the range. Sheep, however, showed a significant positive association with *Agrostis* in April when only the rams were present on the range.

Resting: Fallow does while resting showed a positive relationship with the presence of *Agrostis*, which was significant in 7 months. Bucks were positively correlated with the presence of *Agrostis* in all months but two, but significantly so in only 3 months. Cattle showed a negative association with *Agrostis* in all months, significant only in

Table 3.6.3 Kendall's rank correlation co-efficients (τ)£ for the use of *Festuca rubra* by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	-0.32**	-0.22	-0.20	-0.23	0.08	-0.02	0.00	-0.15
November	0.09	-0.24*	0.03	-0.05	0.16	0.08	---	---
December	-0.14	-0.06	-0.08	-0.04	---	---	---	---
January 1983	-0.10	-0.01	-0.15	-0.13	---	---	---	---
February	0.19	0.24*	0.13	0.00	---	---	---	---
March	-0.24*	-0.12	-0.12	-0.02	---	---	---	---
April	-0.09	-0.06	-0.08	-0.13	0.25*	0.26*	-0.13	-0.11
May	-0.07	-0.10	-0.14	-0.16	0.08	0.06	-0.02	-0.14
June	0.01	-0.02	-0.14	-0.16	0.10	0.15	-0.07	-0.15
July	0.06	-0.14	-0.17	-0.20	-0.00	-0.08	-0.05	-0.13
August	0.09	-0.03	-0.20	-0.16	0.20	0.08	0.09	-0.15
September	0.06	0.05	0.21	0.07	---	---	0.27*	0.31**

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al*. 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.4 Kendall's rank correlation co-efficients (τ)£ for the use of *Agrostis* spp. by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	0.38 **	0.25 *	0.21	0.25 *	-0.12	-0.07	0.00	-0.07
November	0.24 *	0.12	0.02	0.25 *	-0.05	-0.07	---	---
December	0.07	0.30 *	0.09	0.26 *	---	---	---	---
January 1983	-0.14	0.18	-0.13	0.30 *	---	---	---	---
February	0.09 *	0.12	0.11 **	0.22	---	---	---	---
March	0.23 *	0.20	0.30 *	0.21	---	---	---	---
April	0.09	0.11 *	0.18	0.22 *	-0.15	-0.28 *	0.29 *	0.27 *
May	0.06	0.26 *	0.18 *	0.11	-0.13	-0.20	-0.01	0.10
June	-0.13	-0.07	0.28 *	0.21 **	-0.12	-0.17	-0.10	-0.07
July	-0.01	-0.04	0.25 *	0.30 *	0.04	-0.03	-0.03	-0.02
August	0.14	0.10	0.06	0.19 **	-0.16	-0.15	-0.07	-0.08
September	0.16	0.21	0.24 *	0.35 **	---	---	-0.14	-0.01

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al.* 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

April. For sheep, the rank correlation co- efficients were negative in 5 months out of 7. Sheep while resting were, however, significantly positively correlated with *Agrostis* in April when only the rams were present on the range.

Holcus lanatus (Table 3.6.5)

Grazing: Neither sheep nor cattle showed any significant relationship with the abundance of *Holcus*. Fallow bucks and does both showed a consistently negative association with *Holcus*.

Resting: A similar pattern was obtained as for grazing animals: no relationship in the case of cattle and sheep and a consistent avoidance in the case of fallow bucks and does.

Cynosurus cristatus (Table 3.6.6)

Grazing: Sheep were strongly associated with *Cynosurus* in 5 of the 7 months they were on the range, cattle and fallow bucks showed no consistent association, and fallow does showed a consistent avoidance of *Cynosurus* although the co-efficients were not high enough to be significant in one individual month.

Resting: In fallow bucks and does there was a regular negative relationship although statistically significant only in one month. Sheep showed no relationship and cattle were positively and significantly associated with *Cynosurus* in four months out of seven.

Phleum pratense (Table 3.6.7)

Grazing: Sheep were negatively associated with the presence of *Phleum* in all months although significantly so only in two. Cattle were also generally negatively associated but significantly so only in one month. Fallow does were generally positively associated with *Phleum* but not strongly so and fallow bucks showed no consistent pattern.

Table 3.6.5 Kendall's rank correlation co-efficients (τ)£ for the use of *Holcus lanatus* by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	-0.25 *	-0.28 *	-0.39 **	-0.22	-0.01	-0.11	0.17	0.06
November	-0.24 *	-0.32 *	-0.22	-0.21	-0.19	-0.07	---	---
December	0.05	-0.04	0.03	0.03 *	---	---	---	---
January 1983	-0.09	-0.09	-0.09	-0.27	---	---	---	---
February	-0.21	-0.04	-0.11	-0.09	---	---	---	---
March	-0.10	-0.21	-0.12	-0.16	---	---	---	---
April	-0.40 **	-0.42 **	-0.37 **	-0.42 **	0.06	0.15	0.00	-0.20
May	-0.17	-0.16	-0.25 *	-0.31 *	-0.13	0.15	0.03	-0.14
June	-0.10	-0.22 *	-0.20 *	-0.30	-0.12	-0.14 *	0.06	0.00
July	-0.20	-0.24 **	-0.26	-0.21 **	-0.17	-0.23	-0.00	-0.19
August	-0.06	-0.35	-0.18 *	-0.38 **	-0.14	-0.13	0.07	-0.06
September	-0.17	-0.12	-0.26	-0.37	---	---	-0.03	-0.12

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al*. 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.6 Kendall's rank correlation co-efficients (τ)£ for the use of *Cynosurus cristatus* by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	-0.18	-0.22	0.01	-0.11	0.33**	0.27*	0.25*	0.15
November	-0.07	-0.14	-0.05	-0.23	0.05	0.07	---	---
December	0.04	-0.10*	-0.01	-0.14*	---	---	---	---
January 1983	-0.18	-0.25	-0.06	-0.27	---	---	---	---
February	0.18	0.07	0.20	0.05	---	---	---	---
March	-0.10	-0.15	-0.02	-0.18	---	---	---	---
April	-0.05	-0.12	-0.13	-0.20	0.08	0.18***	-0.05*	-0.18
May	0.03	-0.18	-0.14	-0.08	0.08	0.39*	0.22*	0.11
June	0.14	0.14	-0.18	-0.01	0.04	0.22	0.23***	0.12
July	0.17	0.19	-0.08	-0.12	-0.05	0.02*	0.39**	0.11*
August	0.08	-0.06	-0.06	-0.21	0.10	0.26	0.36	0.28
September	-0.05	-0.01	-0.11	-0.22	---	---	-0.19	0.11

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al*. 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.7 Kendall's rank correlation co-efficients (τ)£ for the use of *Phleum pratense* by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	0.33	0.40 *	0.17	0.26 *	-0.33	-0.13	-0.17	-0.09
November	0.16	0.41 **	0.21	0.30 *	-0.07	0.01	---	---
December	0.11	0.35 *	0.12	0.27 *	---	---	---	---
January 1983	0.04	0.07	0.17	0.24	---	---	---	---
February	0.12	-0.03	0.04	0.19	---	---	---	---
March	0.24 *	0.01	0.02	-0.01	---	---	---	---
April	0.33 *	0.26 *	0.21 *	0.21 *	-0.05	-0.09	0.12	0.26
May	0.10	0.20	0.26 *	0.30 *	-0.06	-0.14 *	-0.17	-0.02
June	-0.10	0.03	0.25 *	0.27 *	0.06	-0.26	-0.13 *	-0.04
July	-0.05	-0.11	0.14	0.11 *	-0.01	0.03	-0.28 *	-0.03
August	-0.07	0.16	0.23 *	0.33 *	-0.03	-0.16	-0.29	-0.03
September	-0.04	0.12	0.27	0.29	---	---	-0.20	0.01

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al*. 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Resting: The pattern for resting animals was similar to that for grazing animals.

Ranunculus repens (Table 3.6.8)

None of the herbivores showed any significantly consistent association with *Ranunculus* for either resting or feeding although fallow does did show a significant positive association for feeding in October and November and bucks were significantly associated in October.

Trifolium repens (Table 3.6.9)

Fallow does and bucks both showed a very strong and significant negative association with the occurrence of *Trifolium* both whilst feeding and resting. Neither cattle nor sheep showed any marked associations with *Trifolium*.

Dactylis glomerata (Table 3.6.10)

Fallow bucks and does were positively associated with *Dactylis* abundance whilst grazing in May and feeding cattle were negatively associated in August. Fallow bucks and does were also positively associated with *Dactylis* whilst resting in April, and in May and September respectively. Otherwise there were no significant relationships with *Dactylis*.

***Poa* spp.** (Table 3.6.11)

Cattle and sheep showed no association with the occurrence of *Poa*. Fallow bucks and does showed a general negative association both for feeding and resting.

Anthoxanthum odoratum (Table 3.6.12)

Table 3.6.8 Kendall's rank correlation co-efficients (τ)£ for the use of *Ranunculus* spp. by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	0.26*	0.25*	0.24*	0.06	-0.03	0.00	-0.23	-0.13
November	0.18	0.07	0.24*	0.16	0.11	-0.04	---	---
December	-0.21	-0.25	-0.21	-0.24	---	---	---	---
January 1983	-0.10	0.01	-0.18	0.02	---	---	---	---
February	0.01	0.18	0.01	0.03	---	---	---	---
March	-0.13	-0.07	-0.11	-0.03	---	---	---	---
April	0.01	0.16	-0.03	0.01	0.02	-0.07	-0.10	-0.09
May	-0.16	0.18	0.04	0.18	0.03	-0.10	-0.16	-0.16
June	0.02	-0.12	0.05	-0.13	-0.06	-0.11	-0.05	-0.15*
July	-0.23	-0.17	-0.03*	-0.14	0.04	0.01	-0.13	-0.25
August	-0.07	-0.11	-0.28	-0.16	0.10	0.00	-0.14	-0.20
September	0.14	-0.10	-0.03	0.00	---	---	-0.20	0.07

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al*. 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.9 Kendall's rank correlation co-efficients (τ)£ for the use of *Trifolium repens* by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	-0.45 ***	-0.60 ***	-0.58 ***	-0.49 ***	0.15	0.08	-0.04	-0.12
November	-0.35 **	-0.51 ***	-0.31 **	-0.48 ***	-0.05	-0.07	---	---
December	-0.20	-0.33 **	-0.26 *	-0.28 *	---	---	---	---
January 1983	-0.07	-0.30 *	-0.10	-0.43 **	---	---	---	---
February	-0.24 *	-0.17	-0.27 *	-0.33 **	---	---	---	---
March	-0.33 **	-0.23 **	-0.30 ***	-0.22 ***	---	---	---	---
April	-0.33 **	-0.37 **	-0.43 **	-0.50 ***	0.11	0.07	-0.08	-0.18 **
May	-0.10	-0.12	-0.37 **	-0.43 ***	0.09	0.11	-0.07	-0.28
June	0.08	-0.05	-0.31 *	-0.48 **	0.09	0.11	-0.06	-0.07
July	0.01	-0.03	-0.30 *	-0.32 ***	-0.02	-0.03	-0.03	-0.08
August	-0.07	-0.02	-0.23 ***	-0.41 ***	0.07	0.12	0.13 *	0.01
September	0.04	-0.16	-0.44	-0.50	---	---	-0.24	0.01

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al.* 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.10 Kendall's rank correlation co-efficients (τ)£ for the use of *Dactylis glomerata* by herbivores for grazing or resting

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	0.16	0.09	0.01	-0.07	-0.16	-0.11	-0.09	-0.14
November	0.01	0.12	0.00	0.08	-0.16	-0.05	---	---
December	0.04	0.02	0.01	-0.14	---	---	---	---
January 1983	0.01	0.02	0.14	0.23	---	---	---	---
February	0.07	-0.11	0.08	0.22	---	---	---	---
March	0.01	0.23	0.09	0.14	---	---	---	---
April	0.21 *	0.35 **	0.12 *	0.12 *	0.10	0.08	-0.14	0.00
May	0.23	0.19	0.27	0.30	0.17	0.02	-0.08	0.02
June	0.10	0.05	0.13	0.13	0.03	0.10	-0.15	-0.05
July	-0.06	-0.03	-0.03	0.05	-0.05	0.05	-0.15	0.01
August	0.02	0.09	0.00	0.07 **	-0.17	-0.10	-0.10	-0.09
September	0.16	0.05	0.04	0.36	---	---	-0.03	-0.12

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al*. 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.11 Kendall's rank correlation co-efficients (τ)£ for the use of *Poa* spp. by herbivores for grazing or resting.

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	-0.01	-0.12	-0.08	-0.18	0.22 *	0.13	-0.11	-0.14
November	-0.21 *	-0.15 *	-0.01 *	-0.37 *	0.06	0.04	---	---
December	-0.19 *	-0.30 *	-0.25 *	-0.31 *	---	---	---	---
January 1983	-0.25 *	-0.31 *	-0.25 *	-0.27 *	---	---	---	---
February	-0.04 *	-0.03	-0.10	-0.21	---	---	---	---
March	-0.24 *	-0.14 *	-0.17 *	-0.17 *	---	---	---	---
April	-0.22 *	0.26 *	-0.31 *	-0.28 *	0.02	0.09	-0.05	-0.17
May	0.06 **	0.01 *	-0.22 **	-0.18 *	0.08	0.20	-0.03	-0.14
June	0.33 *	0.25 *	-0.32 *	-0.24 *	0.16	0.10	0.05	-0.04
July	0.15	0.22	-0.23 *	-0.23 *	0.19	0.28	0.21	-0.01
August	0.03	-0.02	0.28	-0.30 *	0.14	0.15	0.13 **	0.04
September	-0.02	-0.13	-0.16	0.26	---	---	0.34	0.06

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al.* 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Grazing: Fallow bucks while grazing showed a definite pattern of association. They were generally negatively associated with *Anthoxanthum* abundance from November to April, significantly so in December and January and positively related from May to October, though the relationship was significant only in June. Cattle also showed a positive association which was not significant. Fallow does and sheep were generally negatively associated with *Anthoxanthum*. Relationship of does with the abundance of *Anthoxanthum* was significant in 5 months out of 10 they were negatively associated.

Resting: Fallow bucks and cattle while resting followed the same general pattern as for grazing. Negative relationship of resting does and sheep with *Anthoxanthum* abundance was even more pronounced, in that they showed negative association in all months.

Cerastium fontanum (Table 3.6.13)

Fallow bucks while grazing were negatively associated with *Cerastium* abundance whereas grazing cattle were positively associated. Cattle and sheep showed a generally positive tendency towards the presence of *Cerastium* whilst resting whereas the bucks and does showed no marked relationship.

Plantago lanceolata (Table 3.6.14)

Fallow does and bucks both showed a strong and significant negative relationship with the abundance of *Plantago* both whilst feeding and resting. Cattle and sheep also showed a negative tendency towards *Plantago* which was significant only with cattle in July.

3.3.2.b General habitat preference

Looking at the plant communities within the range at Hopetoun at a broader level, three main habitat types were identified:

Table 3.6.12 Kendall's rank correlation co-efficients (τ)£ for the use of *Anthoxanthum odoratum* by herbivores for grazing or resting.

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	0.14	-0.18	0.07	-0.17	0.09	0.09	-0.19	-0.22
November	-0.05 *	-0.05 *	-0.06 *	-0.19 *	-0.05	-0.08	---	---
December	-0.28 *	-0.25	-0.32 *	-0.32	---	---	---	---
January 1983	-0.29	-0.25	-0.31	-0.10	---	---	---	---
February	0.10	-0.08	0.00	-0.16	---	---	---	---
March	-0.28	-0.04	-0.19 *	-0.10	---	---	---	---
April	-0.10	-0.10	-0.26	-0.21	-0.01	-0.04	0.02	-0.03
May	0.24 ***	0.13 **	0.07 *	-0.12	0.17	0.16 *	-0.14	-0.24 *
June	0.48	0.44 *	-0.29	-0.06	0.17	0.24	-0.12	-0.28
July	0.20	0.37	-0.20 **	-0.17 *	0.16	0.16	0.13	-0.07
August	0.08	0.11	-0.43	-0.33	0.04	0.11	0.04 *	-0.07
September	0.20	-0.04	-0.10	-0.02	---	---	-0.25	-0.15

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al*. 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.13 Kendall's rank correlation co-efficients (τ)£ for the use of *Cerastium fontanum* by herbivores for grazing or resting.

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	-0.32**	-0.30*	-0.20	-0.37**	0.24*	0.14	0.01	-0.07
November	-0.14	-0.29*	-0.17	-0.38**	0.22	0.00	---	---
December	-0.16	-0.08	-0.18	-0.17	---	---	---	---
January 1983	-0.15	-0.14	-0.10	-0.09	---	---	---	---
February	-0.02	0.06	-0.04	-0.09	---	---	---	---
March	-0.18	0.02	-0.09	-0.10	---	---	---	---
April	0.04	0.03	0.09	0.02	0.19	0.21	-0.16	-0.06
May	0.02	-0.13	-0.15	-0.13	0.15	0.06	0.08	0.08
June	0.06	0.07	-0.11	0.03	0.10	0.23	-0.04	0.03
July	-0.05	0.07	-0.10	-0.09	0.08	0.09	0.01	0.06
August	0.07	-0.04	-0.13	-0.08	0.15	0.13	0.22	-0.01
September	0.13	-0.05	-0.10	0.03	---	---	-0.15	0.07

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al.* 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

Table 3.6.14 Kendall's rank correlation co-efficients (τ)£ for the use of *Plantago lanceolata* by herbivores for grazing or resting.

	Bucks		Does		Cattle		Sheep	
Months	Graz	Rest	Graz	Rest	Graz	Rest	Graz	Rest
October 1982	-0.28 *	-0.40 **	-0.26 *	-0.28 *	-0.16	-0.16	-0.01	-0.01
November	-0.27 *	-0.30 *	-0.14	-0.19	0.02	-0.06	---	---
December	0.01	-0.24	-0.03	-0.15	---	---	---	---
January 1983	0.04	-0.04	-0.01	-0.18	---	---	---	---
February	-0.27 *	-0.27 *	-0.06	-0.24	---	---	---	---
March	-0.23	-0.09	-0.18	-0.14	---	---	---	---
April	-0.22	-0.15	-0.27 *	-0.30 *	-0.24	-0.21	-0.19	-0.15
May	-0.10	-0.30 *	0.08	-0.14	0.11	-0.16	0.01	-0.18
June	0.01	0.02	-0.01 *	-0.15 *	-0.06 *	0.09 **	-0.16	-0.13
July	-0.08	-0.04	-0.26	-0.26	-0.32	-0.39	-0.02	-0.11
August	-0.09	-0.08	-0.10 **	-0.24	-0.20	-0.16	-0.14	-0.13
September	-0.13	-0.19	-0.36	-0.17	---	---	-0.07	-0.20

£ Kendall's rank correlation co-efficients (τ) (Siegel 1956) calculated using SPSS Computer Package (Nie *et al.* 1975).

* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level
--- Cattle / sheep not present
Graz Grazing
Rest Resting

1. Tree groves
2. Shaded areas
3. Grassland areas.

To examine the possibility of general habitat preference at this level I calculated a Habitat Preference Index Ratio (Mishra 1982) as follows:

$$P_{1i} = \frac{Ui}{Ai}$$

whereas P_{1i} is the index of preference of habitat 'i';
Ui is the percentage of all observations, recorded in the habitat 'i'; and
Ai is the percentage of the range area covered by habitat 'i'.

The index varies from 0, when the habitat is totally avoided through 1.0, when no preference is exercised, to higher values by increasing degrees of preference. This in effect is similar to Hunter's (1962) and Colquhoun's (1971) comparative grazing index (CGI) which is P_1 x 100. However, the degree of avoidance (0 - 1.0) is compressed relative to those preferred (1.0 /∞). Bullock (1982) transformed P_1 into a selection ratio as $S = Log_{10} (P_{1i} + 1)$ to obtain a normalized index of preference varying between 0.0 and 1.0, with the threshold point at 0.30. Duncan (1983) used the natural log $(P_1 + 1)$ to normalise the data. The addition of 1, however, distorts the scale especially for smaller index values and instead of being expanded (for better explanation), the results are compressed. Thus avoiding the addition of 1, I calculated:

$$P_{2i} = Log_{10} (P_{1i})$$

The values of P_2 can now range from /∞/-0/∞/ with zero (0) being

the threshold point, where no choice is exercised.

Grazing herbivores (Tables 3.7 and 3.8; Fig. 3.7)

Fallow bucks

Fallow bucks did not show a consistent pattern of use of habitat types. Tree groves were preferred for grazing in October, November and April, and marginally so ($P_2<.10$) in December, January, March and September. Tree groves were avoided marginally in February and strongly from May to August. Bucks did not use tree groves for feeding in June and August.

Shaded areas were preferred in October, February to April (weak preference), and from May to September. Avoidance of shaded areas was shown in November and January (marginally) and in December and May.

Bucks selected grasslands in December and July, and weakly so in January and February. Bucks avoided the grasslands in October (strongly), November, March to June and in August and September. Bucks did not use the habitat for feeding in June.

Fallow does

Fallow does showed a significant positive selection for tree groves for feeding. They avoided the habitat only in July. Does showed a weak selection for shaded areas in November, February and September. Does avoided shaded areas in December, January, May, June and August. No choice was exercised for the grazing use of shaded areas in October, March, April and July.

Does showed a positive selection for grasslands for feeding only in December and August, and a weak selection in January and July. Does avoided grasslands for feeding in October, November, from February to June and in September.

Table 3.7 Utilization of habitat types for grazing by herbivores ,numbers

Month	Habitat type	Bucks	Does	Cattle	Sheep
October 1982	Tree groves	34	440	316	169
	Shaded areas	61	587	1109	533
	Grassland	4	152	950	1051
November	Tree groves	35	154	177	---
	Shaded areas	48	269	376	---
	Grassland	28	48	189	---
December	Tree groves	40	189	---	---
	Shaded areas	30	91	---	---
	Grassland	104	333	---	---
January 1983	Tree groves	27	128	---	---
	Shaded areas	46	202	---	---
	Grassland	40	195	---	---
February	Tree groves	20	78	---	---
	Shaded areas	59	300	---	---
	Grassland	37	118	---	---
March	Tree groves	41	179	---	---
	Shaded areas	90	341	---	---
	Grassland	39	167	---	---
April	Tree groves	49	259	28	33
	Shaded areas	107	363	132	321
	Grassland	21	95	85	18
May	Tree groves	25	330	159	597
	Shaded areas	125	315	589	3006
	Grassland	22	122	231	3030
June	Tree groves	1	530	100	1539
	Shaded areas	327	280	393	5809
	Grassland	4	150	131	5452
July	Tree groves	11	112	240	591
	Shaded areas	278	334	807	5494
	Grassland	55	249	487	3831
August	Tree groves	6	212	105	937
	Shaded areas	275	224	357	4453
	Grassland	56	389	262	3815
September	Tree groves	27	150	---	487
	Shaded areas	85	252	---	2577
	Grassland	11	36	---	1652

Table 3.7.a Proportions of herbivores using habitat types for grazing.

Month	Habitat type	Bucks	Does	Cattle	Sheep
October 1982	Tree groves	34	37	13	10
	Shaded areas	62	50	47	30
	Grassland	4	13	40	60
November	Tree groves	32	33	24	---
	Shaded areas	43	57	51	---
	Grassland	25	10	25	---
December	Tree groves	23	31	---	---
	Shaded areas	17	15	---	---
	Grassland	60	54	---	---
January 1983	Tree groves	24	24	---	---
	Shaded areas	41	39	---	---
	Grassland	35	37	---	---
February	Tree groves	17	16	---	---
	Shaded areas	51	60	---	---
	Grassland	32	24	---	---
March	Tree groves	24	26	---	---
	Shaded areas	53	50	---	---
	Grassland	23	24	---	---
April	Tree groves	28	36	11	9
	Shaded areas	60	51	54	86
	Grassland	12	13	35	5
May	Tree groves	14	43	16	9
	Shaded areas	73	41	60	45
	Grassland	13	16	24	46
June	Tree groves	1	55	16	12
	Shaded areas	98	29	63	45
	Grassland	1	16	21	43
July	Tree groves	3	16	16	6
	Shaded areas	81	48	53	55
	Grassland	16	36	31	39
August	Tree groves	2	26	15	10
	Shaded areas	82	27	49	49
	Grassland	16	47	36	41
September	Tree groves	22	34	---	10
	Shaded areas	69	58	---	55
	Grassland	9	8	---	35

Table 3.8 Habitat Preference Index (P_2)

Preference exercised by herbivores for grazing on habitat types.

Months	Fallow bucks			Fallow does			Cattle			Sheep		
	h1	h2	h3	h1	h2	h3	h1	h2	h3	h1	h2	h3
October	.24	.10	-.88	.27	.00	-.38	-.17	-.02	.11	-.31	-.21	.29
November	.20	-.05	-.09	.21	.07	-.48	.08	.01	-.09	---	---	---
December	.06	-.46	.29	.19	-.52	.24	---	---	---	---	---	---
January	.08	-.08	.06	.09	-.10	.08	---	---	---	---	---	---
February	-.07	.01	.01	.17	.09	-.11	---	---	---	---	---	---
March	.08	.03	-.13	.11	.00	-.10	---	---	---	---	---	---
April	.14	.09	-.42	.26	.01	-.37	-.24	.04	.05	-.36	.25	-.80
May	-.14	.17	-.39	.33	-.08	-.29	-.09	.09	-.11	-.21	.07	-.01
June	*	.30	*	.44	-.22	-.30	-.09	.11	-.17	-.22	-.01	.14
July	-.80	.22	.28	-.09	-.01	.06	-.10	.03	.01	-.52	.05	.10
August	*	.22	-.27	.11	-.26	.18	-.14	.00	.07	-.29	-.01	.13
September	.04	.15	-.54	.23	.07	-.57	---	---	---	-.28	.05	.05

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

* No animals grazing in the habitat

--- Cattle/sheep not present on the range

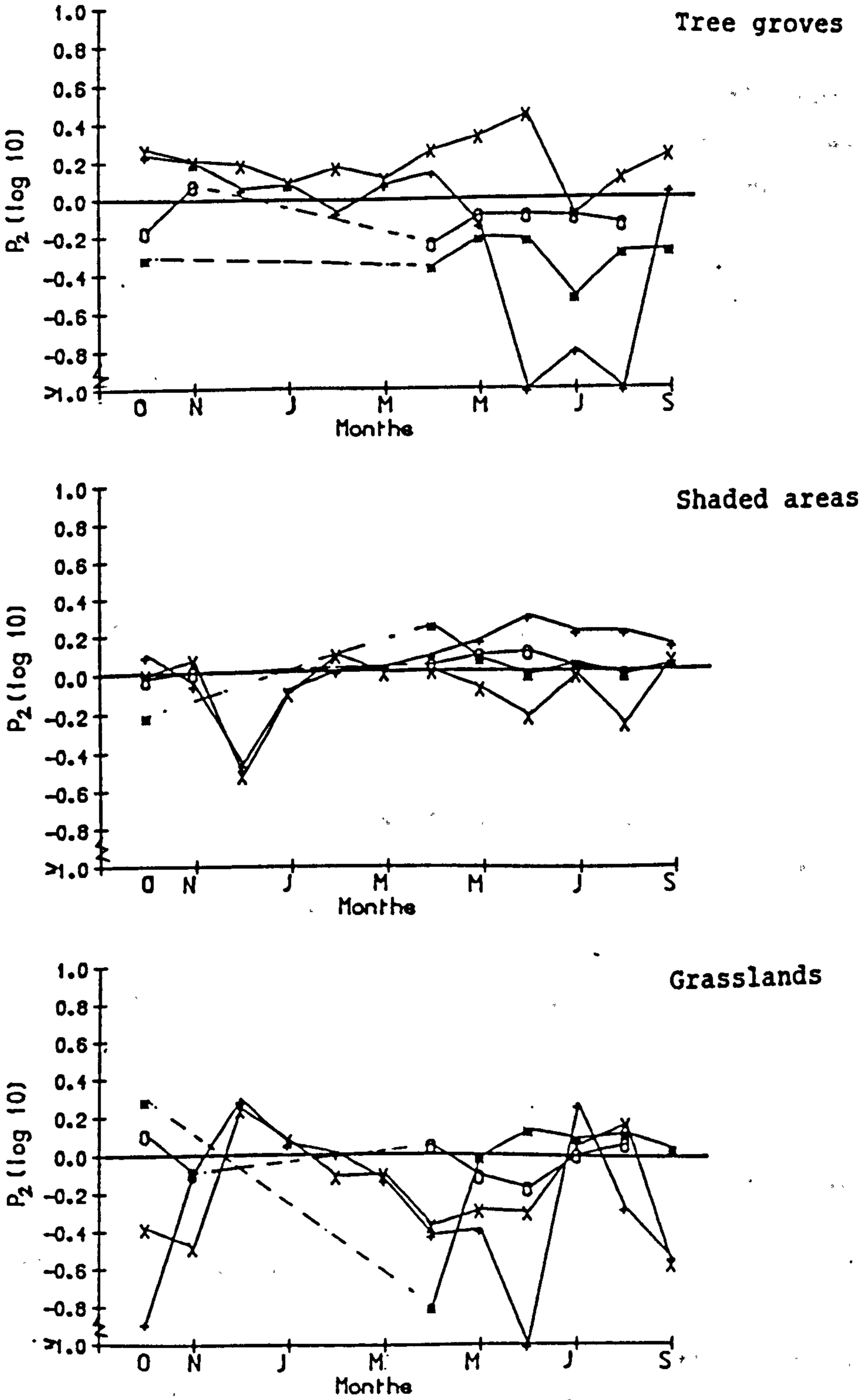


FIG. 3.7 Habitat Preference Index for the seasonal use of habitat types by herbivores for grazing.

—*—*— SHEEP
—O—O— CATTLE
—×—×— DOES
—+—+— BUCKS

Cattle

Cattle avoided tree groves for feeding in all months except November when they marginally selected these areas. They showed a preference for shaded areas for feeding in May and June. In all other months use of shaded areas for grazing was marginal, with little exercise of choice.

Cattle preferred grassland areas in October and August, avoided these in November, May, June and exercised no choice in April and July.

Sheep

Sheep significantly avoided tree groves for feeding in all months. Shaded areas were selected in April, May, avoided in October and generally no selection was shown either way in other months.

Rams in April showed a strong avoidance of grasslands for feeding. Sheep selected grassland areas in all other months except May when they exercised no choice.

Resting herbivores (Tables 3.9 and 3.10, Fig 3.8)

Fallow bucks

Fallow bucks showed no significant pattern in the use of tree groves and shaded areas for resting, but showed a significant avoidance of grassland areas.

Tree groves were positively selected for resting from October to February, avoided in May to August, and almost no choice was exercised in March and April. Tree groves were not used for resting in July and August.

Table 3.9 Utilization of habitat types for resting by Herbivores ,numbers.

Month	Habitat type	Bucks	Does	Cattle	Sheep
October 1982	Tree groves	100	249	66	40
	Shaded areas	62	126	229	95
	Grassland	10	78	312	271
November	Tree groves	34	74	13	---
	Shaded areas	31	47	69	---
	Grassland	4	1	36	---
December	Tree groves	27	102	---	---
	Shaded areas	6	45	---	---
	Grassland	6	69	---	---
January 1983	Tree groves	27	95	---	---
	Shaded areas	27	116	---	---
	Grassland	4	0	---	---
February	Tree groves	31	98	---	---
	Shaded areas	27	169	---	---
	Grassland	29	66	---	---
March	Tree groves	37	121	---	---
	Shaded areas	125	384	---	---
	Grassland	34	106	---	---
April	Tree groves	42	109	3	149
	Shaded areas	114	229	49	304
	Grassland	34	85	39	0
May	Tree groves	19	245	57	1000
	Shaded areas	109	200	331	1420
	Grassland	12	100	181	1495
June	Tree groves	12	385	51	2131
	Shaded areas	267	290	348	1217
	Grassland	5	132	171	3713
July	Tree groves	0	206	134	1180
	Shaded areas	429	416	1146	4235
	Grassland	22	189	557	2569
August	Tree groves	5	267	26	475
	Shaded areas	306	249	398	3306
	Grassland	76	211	293	2608
September	Tree groves	32	128	---	327
	Shaded areas	67	59	---	782
	Grassland	30	0	---	516

Table 3.9.a Proportions of herbivores using habitat types for resting.

Month	Habitat type	Bucks	Does	Cattle	Sheep
October 1982	Tree groves	58	55	11	10
	Shaded areas	36	28	38	23
	Grassland	6	17	51	67
November	Tree groves	49	61	11	---
	Shaded areas	45	38	58	---
	Grassland	6	1	31	---
December	Tree groves	69	47	---	---
	Shaded areas	15	21	---	---
	Grassland	16	32	---	---
January 1983	Tree groves	47	45	---	---
	Shaded areas	46	55	---	---
	Grassland	7	0	---	---
February	Tree groves	36	29	---	---
	Shaded areas	31	51	---	---
	Grassland	33	20	---	---
March	Tree groves	19	20	---	---
	Shaded areas	64	63	---	---
	Grassland	17	17	---	---
April	Tree groves	22	22	3	33
	Shaded areas	60	61	54	67
	Grassland	18	17	43	0
May	Tree groves	14	45	10	26
	Shaded areas	78	37	58	36
	Grassland	8	18	32	38
June	Tree groves	4	48	9	30
	Shaded areas	94	36	61	17
	Grassland	2	16	30	53
July	Tree groves	0	26	7	15
	Shaded areas	95	51	63	53
	Grassland	5	23	30	32
August	Tree groves	1	37	4	7
	Shaded areas	79	34	55	41
	Grassland	20	29	41	52
September	Tree groves	25	68	---	20
	Shaded areas	52	32	---	48
	Grassland	23	0	---	32

Table 3.10 Habitat Preference Index (P_2)

Preference exercised by herbivores for resting on habitat types.

Months	Fallow bucks			Fallow does			Cattle			Sheep		
	h1	h2	h3	h1	h2	h3	h1	h2	h3	h1	h2	h3
October	.46	-.13	-.72	.44	-.24	-.25	-.27	-.11	.22	-.31	-.32	.33
November	.39	-.05	-.72	.48	-.10	*	-.25	.08	-.01	---	---	---
December	.54	-.51	-.30	.37	-.37	.01	---	---	---	---	---	---
January	.37	-.02	-.66	.35	.05	*	---	---	---	---	---	---
February	.25	-.20	.03	-.04	.01	-.19	---	---	---	---	---	---
March	-.03	.11	-.25	.00	.11	-.25	---	---	---	---	---	---
April	.05	.09	-.24	.05	.09	-.25	-.80	.04	.14	.21	.14	*
May	-.17	.20	-.55	.43	-.20	-.30	-.30	.08	.01	-.31	.06	.03
June	-.68	.28	*	.38	-.14	-.28	-.35	.10	-.01	.18	-.46	.03
July	*	.29	-.80	.10	.02	-.12	-.44	.10	-.01	-.13	.03	.01
August	*	.21	-.20	.26	-.15	.03	-.74	.05	.12	-.43	.03	.12
September	.09	.03	-.13	.53	-.19	*	---	---	---	-.00	-.01	.01

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

* No animals grazing in the habitat

--- Cattle/sheep not present on the range

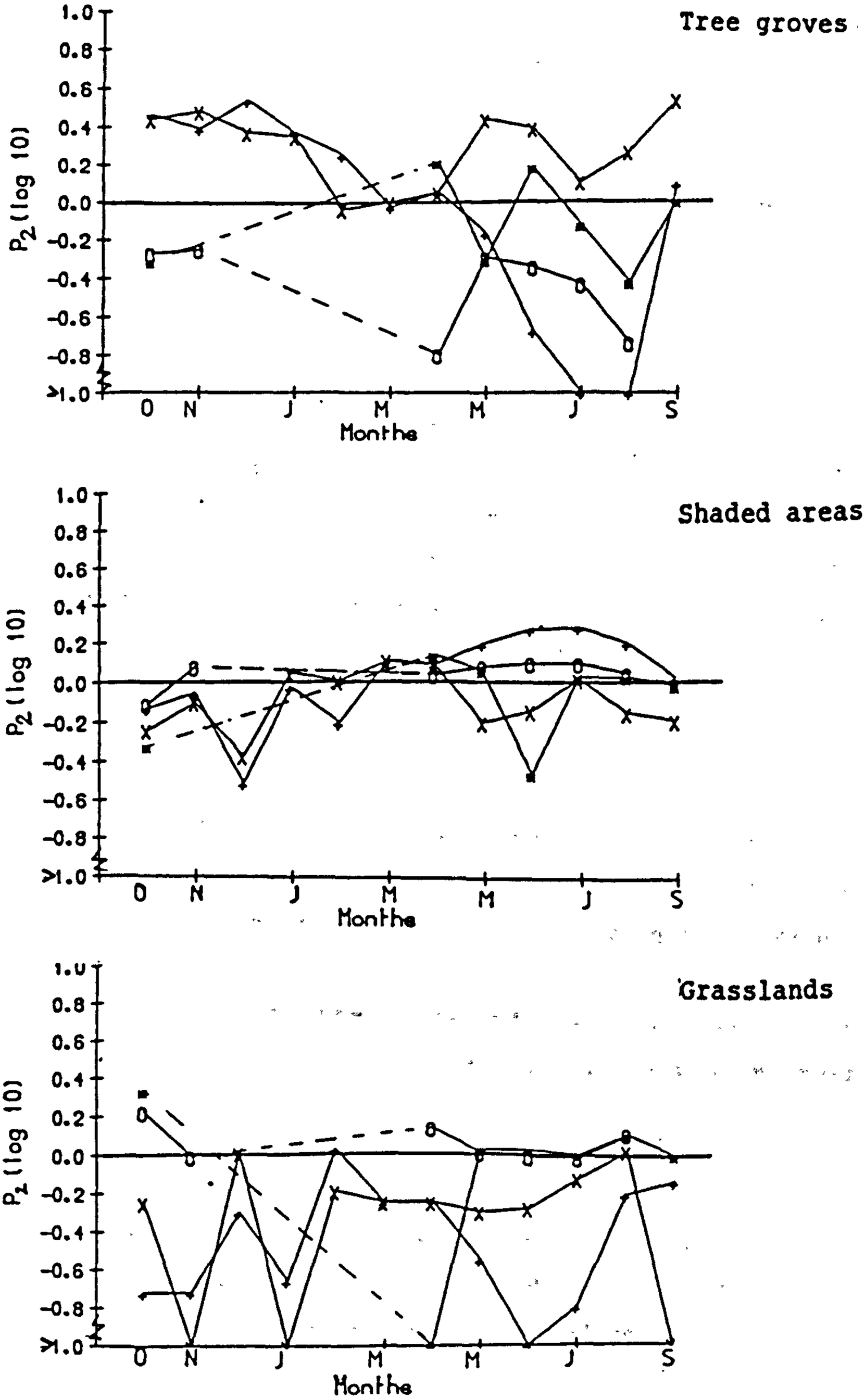


FIG. 3.8 Habitat Preference Index for the seasonal use of habitat types by herbivores for resting.

Bucks positively selected shaded areas for resting from March to September and avoided these from October to February. Selection in September and avoidance in January was, however, marginal.

Grassland areas were not used for resting in June. Bucks use of grasslands in February was marginal.

Fallow does

Fallow does showed a positive preference for tree groves for resting, in all months, and a negative selection for grassland areas. Does did not exercise any choice in the use of tree groves for resting in February and March. They avoided shaded areas for resting from October to November and in May, June, August and September. Does positively selected shaded areas from January to April.

Cattle

Cattle showed a negative preference for tree groves for resting in all months. Cattle showed a positive selection for shaded areas for resting in all months except in October when these were avoided.

Cattle preferred to use grassland areas for resting in October, April and August, and showed no selection either way in other months.

Sheep

Sheep positively selected tree groves for resting in April (when only rams were present on the range) and June, avoided these areas in October, May, July and August, and exercised no choice in September.

The rams positively selected shaded areas in April. Sheep avoided shaded areas in June and showed no selection for these areas either way in other months.

Sheep positively selected grassland areas in October and August, and showed a marginal positive preference in other months except April, when the rams (present on the range) did not use the area.

3.4 DISCUSSION

For most of the plant species examined there was no relationship between the frequency of occurrence of the species and the distribution of foraging animals. However, in a few cases significant relationships were obtained and in some cases different relationships were evident with different herbivores. At the broader level of general habitats some degree of selection was also evident and differences between herbivores were apparent.

These relationships must, however, be examined in greater detail to determine their validity and causes. To a certain extent an examination of causes is dependent upon a knowledge of the diet selection of the herbivores, the subject of a later chapter. Therefore, discussion of this will be deferred until later. At this stage it is important to establish the validity of the relationships obtained.

Lolium was the only plant species which was consistently positively related to the distribution of all the herbivores. *Lolium* showed no relationship with any of the other plant species (Table 3.3 and 3.6.2). This strongly suggests that the observed relationship with the abundance of animals was a genuine one.

The distribution of bucks and does was positively related to tree cover in October and November, during the period of rut. The density of trees was negatively related to the densities of 3 plant species, *Cynosurus*, *Anthoxanthum* and *Plantago*, but only positively related to one, *Agrostis tenuis*. The distribution of bucks and does at the time of the rut was also positively related to the distribution of *Agrostis*. Thus it is not possible to separate with certainty the

association with trees and that with *Agrostis*. Throughout the rest of the year there was a generally positive relationship between does and *Agrostis* but not so with bucks. It is possible that during the rut the bucks were attracted to where the does preferred to feed. Another possibility is that the bucks preferred to rut in the vicinity of trees, using the trees as reference points or for some other social function.

The distribution of grazing sheep was negatively related to the distribution of trees, i.e. the sheep preferred to graze in the open. However, were the sheep avoiding the tree covered areas because of the trees themselves, or were they foraging in the open because of the presence there of a favoured food supply ? The distribution of *Cynosurus* was positively related to the distribution of the sheep, and negatively related to the distribution of trees. It is, therefore, possible that the sheep preferred to feed in areas of high *Cynosurus* density. This will be examined again in conjunction with the data on diet.

The distribution of fallow bucks and does was consistently negatively related to the abundance of *Holcus*. *Holcus* was not significantly associated with any other plant species. Thus it seems likely that fallow avoided the *Holcus* dominated areas.

It is interesting that apart from the association with distribution of *Lolium* the cattle showed little relationship with the distribution of the other plant species.

At the broader level of the general habitat types, fallow showed a consistent preference for the more tree covered areas, the tree groves and the shaded areas. Fallow are of course a woodland species and it would be reasonable to expect that even the semi-domesticated animals would still prefer their original habitat. Although there is no need for protection from predators in Hopetoun Park, the tree covered areas still offer considerable microclimatological advantages;

wind speeds are considerably lowered by the trees and the radiation to and from the sky would also be reduced. In the New Forest, fallow feed in nearby fields but only where shelter is closely available. Within the forest they prefer to feed along the rides and firebreaks (Jackson 1974). However, introduced fallow in California feed in open grassland and are extending their range into livestock grazing areas (Wehaussen and Elliott 1982).

3.5 SUMMARY

1. The vegetation of the park was surveyed. Interrelationship of plant species was determined by Principal Component Analysis (PCA) and Kendall's rank correlation co-efficients(T).
2. Important significant relationships were determined between the number of trees and *Agrostis* spp., and significant negative correlations between number of trees and *Cynosurus cristatus*, *Anthoxanthum odoratum* and *Plantago lanceolata*. *Lolium* showed no association with other species.
3. The parkland habitat was divided into 3 broad categories: tree groves, shaded areas and grassland areas, using PCA.
4. The distribution of herbivores while grazing and resting during the day was studied in relation to the plant species abundance using Kendall's rank correlation co-efficients.
5. Herbivores were positively significantly associated with the distribution of *Lolium*, while grazing or resting.
6. Sheep were negatively associated with the distribution of trees.
7. *Festuca*, *Holcus*, *Cynosurus*, *Poa*, *Trifolium* and *Plantago* were negatively associated with deer. *Holcus* and *Cynosurus* showed a positive relationship with cattle and deer respectively.
8. Habitat Preference Index ratios were calculated for the use of habitat types for grazing and resting by herbivores. Bucks and cattle selected shaded areas during summer. Does generally

preferred tree groves, whereas sheep preferred grasslands. During winter deer preferred tree groves for resting and shaded areas for grazing.

4 GRAZING BEHAVIOUR, DAILY ACTIVITY AND MOVEMENTS

4. GRAZING BEHAVIOUR, DAILY ACTIVITY AND MOVEMENTS

4.1. INTRODUCTION

Herbivores have been known to spend more time grazing than resting at least during daylight hours. Rawes and Welch (1964) have noted that the proportion of grazing sheep in the northern Pennines was always in excess of the non-grazing; 60 % grazing and at some times all of them were grazing. Hughes *et al* (1975) also showed that at least 70 % of the sheep population in the mountains of NW Wales, were actively grazing during daylight hours. This has also been shown for cattle (Hughes and Reid 1951; Arnold and Dudzinski 1978), for Soay sheep (Grubb and Jewell 1974), for feral goats and hill sheep (Bullock 1982), for sheep and red deer (Colquhoun 1971). Grazing in ruminants is interspersed with periods of rest and rumination. Such rhythms have been reported for domestic sheep by Tribe (1949), Hughes and Reid (1951), Arnold (1962), Hunter (1962), Hafez *et al.* (1975b), Colquhoun (1971), Bullock (1982); for Soay sheep (Grubb and Jewell 1974), for bighorn sheep (Geist 1971), dall ram (Hoeffs 1974), for cattle (Hafez *et al.* 1975a), elk (Altmann 1956), red deer (Colquhoun 1971; Clutton-Brock *et al* 1982), fallow deer (Jackson 1974; Chapman and Chapman 1975), Chanler's mountain reedbuck(*Redunca fulvorufula chanleri*) (Irby 1982).

In general ruminants show a similar behaviour i.e. grazing intensively around sun rise, resting around mid-day and intense grazing again in the afternoon until before or after dusk. These rhythms have also been reported to continue into the night for sheep (Tribe 1949), for sheep and cattle (Hughes and Reid 1951; Arnold and Dudzinski 1978), and for red deer (Colquhoun 1971; Clutton-Brock *et al.* 1982). Comparisons of diurnal rhythms of activity between herbivores have been made for red deer and hill sheep (Colquhoun 1971; Osborne 1984), for feral goats and hill sheep (Bullock 1982). But such comparisons have been made in upland areas and not on pasturelands.

Herbivores have also been reported to move while grazing during the course of the day. Sheep movements have been well documented in the studies on hill sheep in Britain. Cattle have been reported to cover about 4 km per day while grazing (Hafez *et al.* 1975a). Red deer (Colquhoun 1971; Clutton- Brock *et al* 1982) and fallow deer also move while grazing (Chapman and Chapman 1975). Use of different altitudes at different times of the day has also been shown in the studies mentioned above (except the study on fallow deer).

In this study I compared the daily and seasonal grazing pattern of the herbivores at Hopetoun concentrating on variations in feeding activity and on movements between the available habitats.

4.2 METHODS

To determine the relationships between the distribution of the animals and the vegetation types available to them observations were made on an hourly basis for all daylight hours of one 24 hour period each week throughout the year (Chapter 3). At the same time as recording the locations of all the animals I also recorded their activity. It is these data on activity patterns that are analysed in this section.

4.3 RESULTS

4.3.1 Diurnal Grazing Activity

Data were collected on diurnal grazing activity in all months of the year but here I will examine in detail the data for only two months representing mid-summer (July) and mid-winter (January).

In July all three species of herbivores were on the range thereby allowing comparisons to be made amongst them. All species showed a distinct diurnal pattern of activity during the daylight hours over

which they were observed, but there were significant differences between them (Table 4.1, Fig. 4.1). Individuals were observed grazing at all times of day but there were definite peaks and troughs of activity within the populations. Most fallow does were found to be grazing during the first observation period in the very early morning (0300 - 0600 hours). Thereafter the proportion of the population observed grazing fell reaching at its lowest level around mid-day and then increased again towards the afternoon. A high proportion were still grazing at the last observation period in the late evening (2000 - 2300 hours). The individuals in the population were not individually marked and were also not individually recognisable. It was, therefore, not possible to examine this pattern of behaviour at the individual level.

Fallow bucks showed a very different pattern from that of the does. There was no evidence of an early morning peak in activity. However, there was a suggestion of slight peak later in the morning from 08.00 - 10.00 hours. There was a subsequent trough in feeding activity but this occurred about 2 hours later than that of the does. The peak in grazing occurred in the late afternoon from 16.00 - 18.00 hours and thereafter grazing activity fell markedly.

Sheep and cattle showed very similar patterns of activity. Both had a peak of activity from 06.00 - 08.00 hours and a trough from 12.00 - 16.00 hours. The number of individuals observed grazing then increased steadily to reach a maximum in the late evening.

In January only fallow bucks and does were on the range and daylight hours were much shorter. In both bucks and does there was much less evidence of a diurnal pattern in foraging(Table 4.2, Fig 4.2). Grazing activity remained very high throughout daylight hours. Both sexes showed a slight trough in activity between 10.00 and 12.00 hours and there was a suggestion of a second trough in the females in the late afternoon (16.00 - 18.00 hours).

Table 4.1 Percentage of time spent grazing and resting in relation to time of day, July 1983.

Time span (GMT)	Bucks G	Bucks R	Does G	Does R	Cattle G	Cattle R	Sheep G	Sheep R	X^2 £	P
0300-0600	32	68	63	37	40	60	20	80	270	.0001
0601-0800	31	69	30	70	58	42	68	32	147	.0001
0801-1000	51	49	42	58	22	78	35	65	40	.001
1001-1200	41	59	31	69	51	49	46	54	23	.001
1201-1400	42	58	29	71	27	73	20	80	34	.001
1401-1600	29	71	49	51	44	56	39	61	12	.01
1601-1800	70	30	60	40	52	48	79	21	84	.001
1801-2000	34	66	64	36	73	27	85	15	181	.0001
2001 2300	37	63	62	38	65	35	85	15	284	.0001

£ X^2 calculations based on the raw data in Appendix 4.1. X^2 calculated to test the signifcance of differences amongst herbivores in grazing behaviour.

G Grazing

R Resting

Each figure calculated from 5 days of observations.

Percentages are given to the nearest whole number.

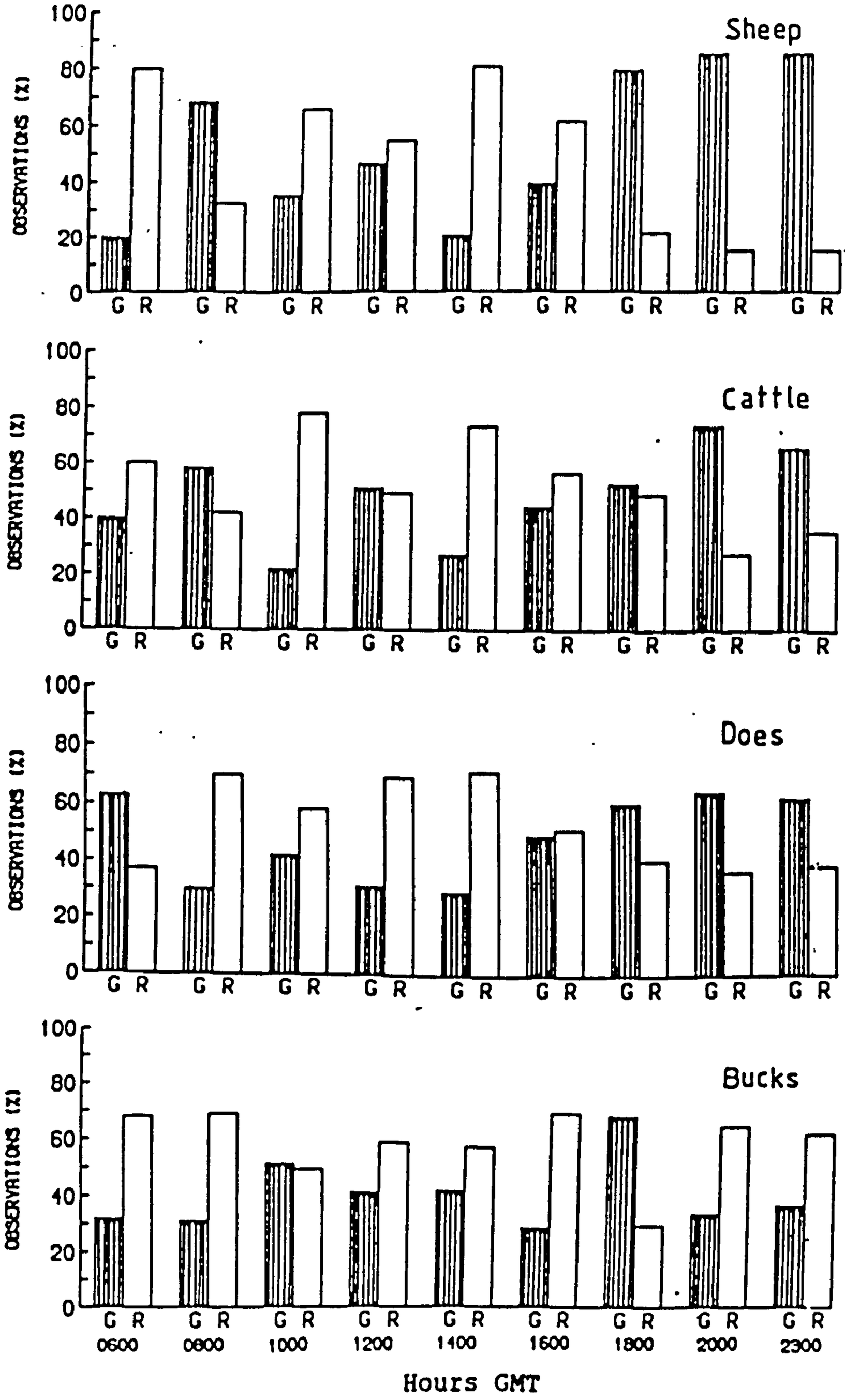


FIG. 4.1 Diurnal grazing behaviour of herbivores in July.

G grazing R resting

Table 4.2 Percentage of time spent grazing and resting in relation to time of day, January, 1983.

Time span (GMT)	Bucks G	Bucks R	Does G	Does R	X^2 £	P
0801-1000	88	12	88	12	0	0
1001-1200	53	47	62	38	1.1	N.S.
1201-1400	65	35	70	30	.4	N.S.
1401-1600	63	37	86	14	10.9	.001
1601-1800	65	35	60	40	.2	N.S.

£ X^2 calculations based on the raw data in Appendix 4.2
X^2 calculated to test the significance of differences between fallow bucks and does.

Percentages are given to the nearest whole number.

G Grazing

R Resting

N.S.Non significant

Each figure calculated from 4 days of observations.

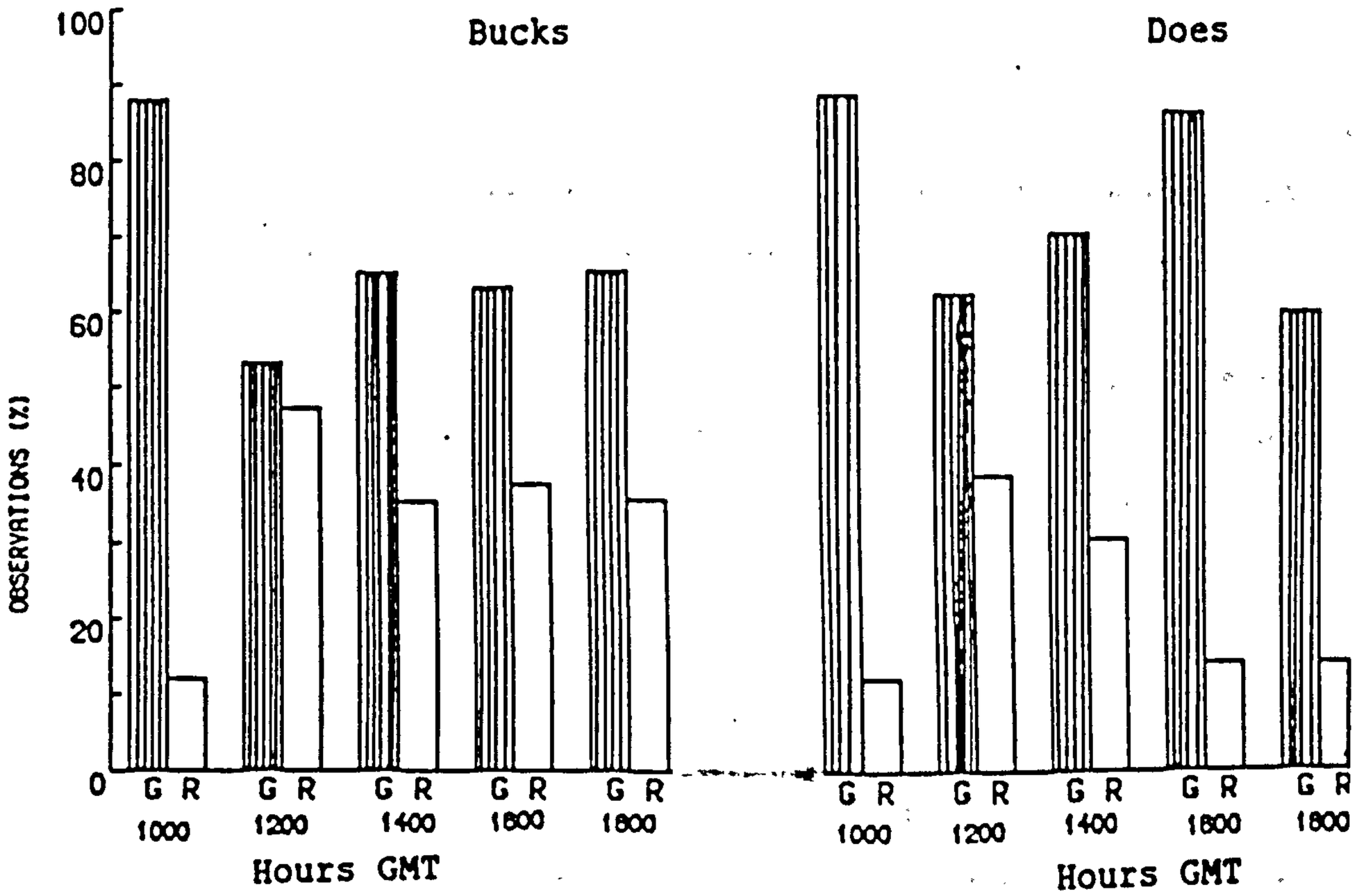


FIG. 4.2 Diurnal grazing behaviour of fallow bucks and does in January.

G grazing R resting

4.3.2 Seasonal Grazing Activity

Fallow bucks and does showed a clear seasonal pattern in the proportion of daylight hours spent grazing (Table 4.3, Fig. 4.3). For the does the pattern was relatively simple with a higher percentage of daylight hours spent feeding in winter than in summer. For the bucks there was a similar pattern except that it was complicated further by the expected drop in foraging activity during the rut which peaked in October.

Cattle and sheep were not on the range during the most severe winter months but nevertheless they also showed a seasonal pattern with the lowest proportion of time spent feeding in summer.

In all the herbivores and for all months of the year more time was spent foraging than resting. The only major exception was the fallow bucks during the rut but even then they still spent about 40 % of their daylight hours foraging.

4.3.3 Diurnal Use of Habitat Types

I calculated Habitat Preference Index (HPI) for the diurnal use of habitat types by herbivores for grazing or resting following the method described in Chapter 3 (see page 53).

Grazing

Fallow bucks preferred shaded areas for grazing in July (Table 4.4, Fig. 4.4). Tree groves were used only from 08.01 - 12.00 hours, when a weak preference was shown. Grasslands were either not used or were not preferred. Does preferred tree groves for grazing up to 08.00 hours and from 10.01 - 12.00 hours, and again from 16.01 - 18.00 hours. Shaded areas were preferred only from 12.01 - 14.00 hours. Grasslands were avoided up to 14.00 hours after which these were

Table 4.3 Percentage of time spent grazing and resting in relation to season.

Months	Bucks		Does		Cattle		Sheep		X^2 £	P
	G	R	G	R	G	R	G	R		
October	37	63	72	28	80	20	81	19	302	.0001
November	62	38	79	21	86	14	--	--	60	.0001
December	82	18	74	26	--	--	--	--	5.4	.025
January	66	34	71	29	--	--	--	--	1.8	N.S.
February	57	43	60	40	--	--	--	--	0.5	N.S.
March	46	54	53	47	--	--	--	--	4.8	.05
April	48	52	59	41	73	27	45	55	92	.0001
May	55	45	58	42	63	37	63	37	17	.001
June	54	46	54	46	52	48	64	36	154	.0001
July	43	57	46	54	45	55	55	45	178	.0001
August	47	53	53	47	50	50	59	41	93	.0001
September	49	51	70	30	--	--	74	26	83	.0001

£ X^2 calculations based on the raw data in Appendix 4.3.
X^2 calculated to test the significance of differences amongst herbivores.

G Grazing

R Resting

Percentages are given to the nearest whole number.

N.S.Non significant

-- Cattle/sheep not present on the range.

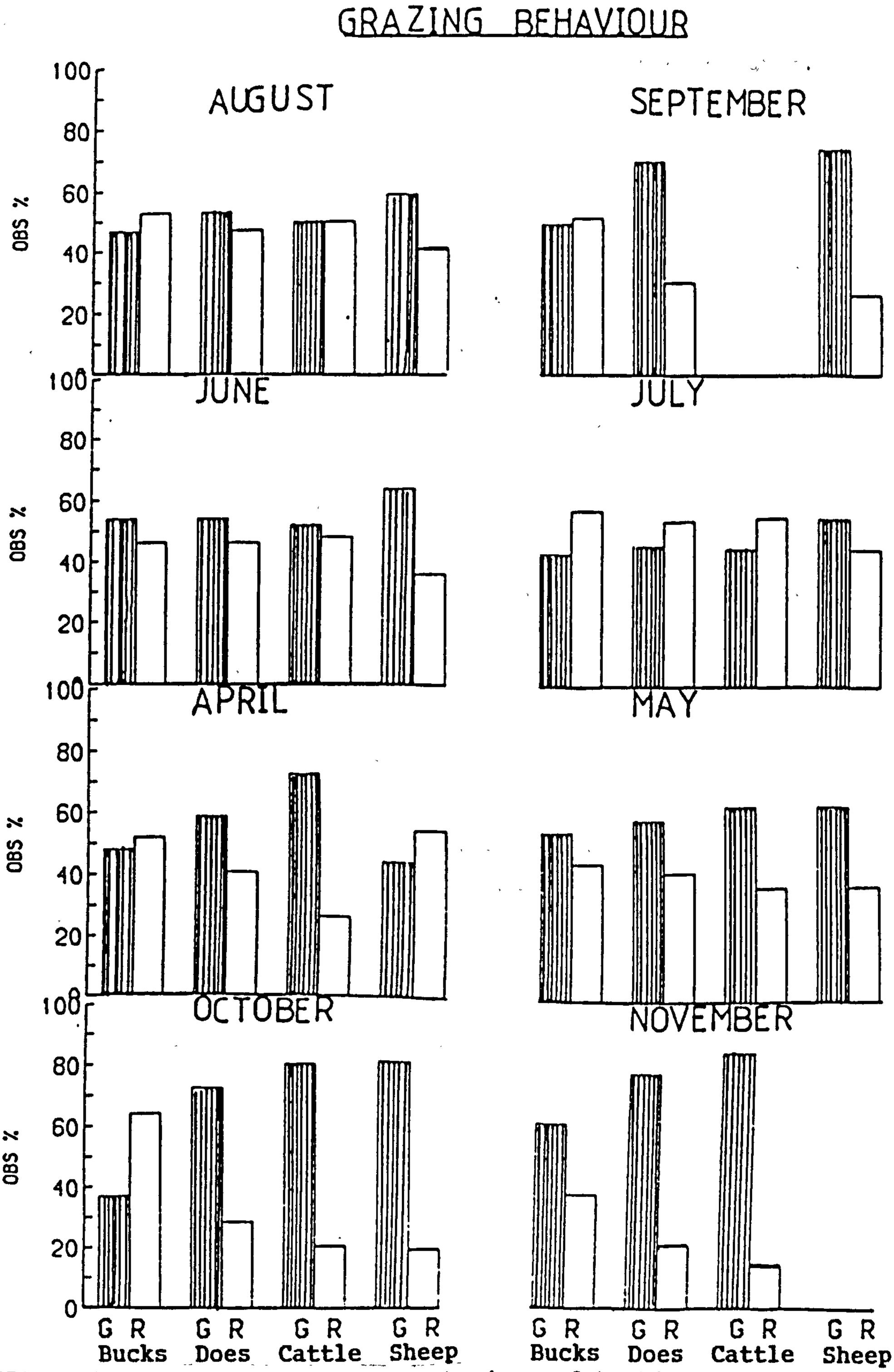


FIG. 4.3 Seasonal grazing behaviour of herbivores.

G grazing R resting

Table 4.4 Habitat Preference Index (P_2)
Preference for the use of habitat types for grazing in relation to time of day, July 1983.

Time span (GMT)	Fallow bucks			Fallow does			Cattle			Sheep		
	h1	h2	h3	h1	h2	h3	h1	h2	h3	h1	h2	h3
0300-0600	*	.06	.15	.06	.05	-.16	-.42	.15	-.11	.06	*	.38
0601-0800	*	.31	*	.35	-.13	-.21	-.56	-.03	.20	.00	.22	-.23
0801-1000	.05	.09	-.22	-.08	.08	-.09	*	.07	.15	-.90	.25	-.45
1001-1200	.09	.19	*	.18	.05	-.32	.31	-.28	.03	*	.09	.10
1201-1400	*	.31	*	*	.19	-.10	*	.17	-.05	-1.3	-.03	.24
1401-1600	*	.31	*	-.39	-.18	.28	-.39	.23	-.58	-.42	.10	-.02
1601-1800	*	.18	-.07	.38	*	.23	-.05	-.05	.09	.00	.00	.02
1801-2000	*	.31	*	-.17	-.08	.17	.03	.01	.03	-.64	.03	.16
2001-2300	*	.18	-.08	.05	-.11	.11	-.05	.01	.01	-.51	.03	.13

HPI calculated on the data in Appendix4.4.

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

* No animals grazing in the habitat.

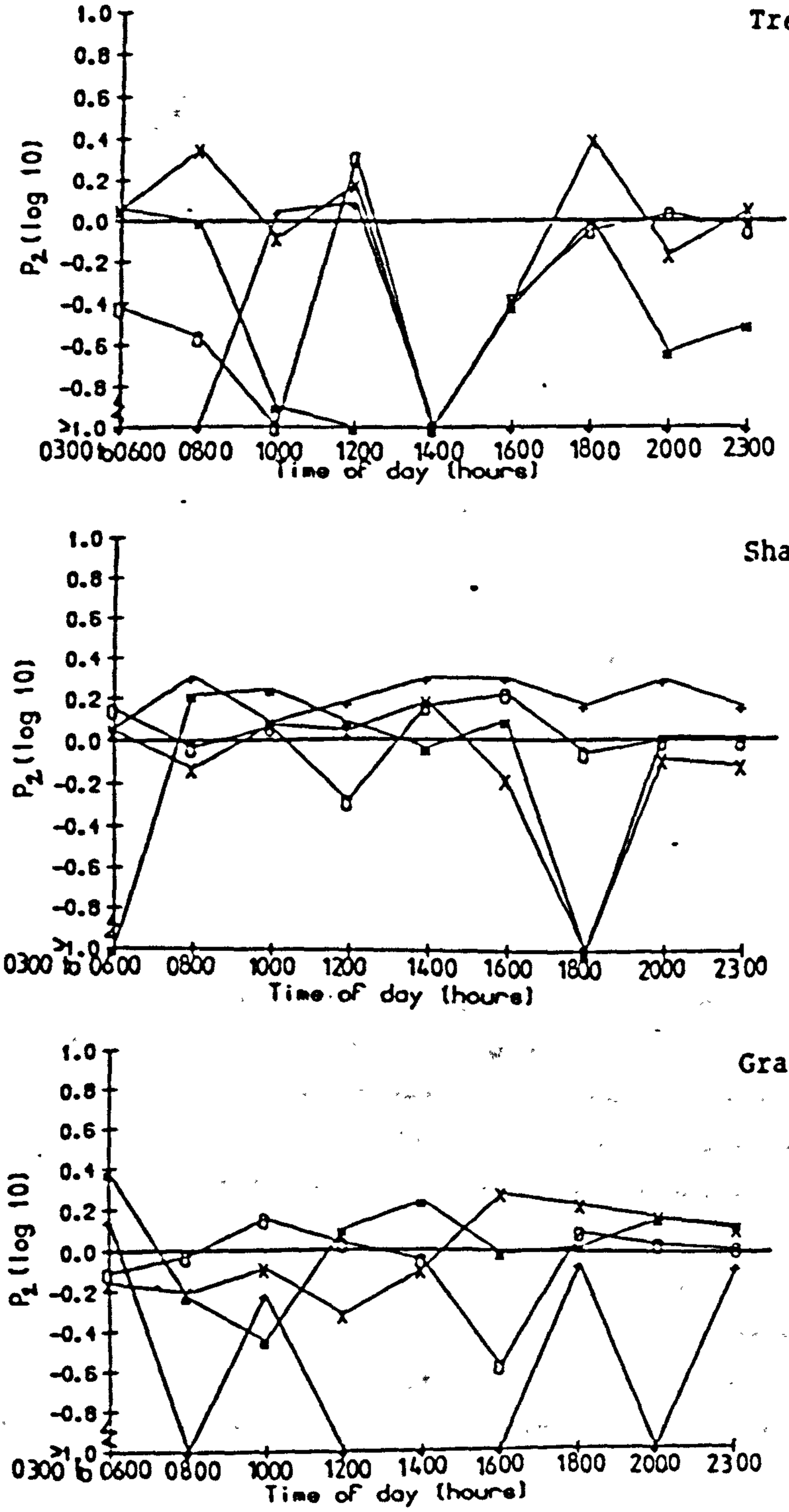


FIG. 4.4 Habitat Preference Index for grazing for herbivores in July, in relation to time of day.

continuously preferred until dusk.

Cattle grazed in tree groves only from 10.01 - 12.00 hours, and preferred shaded areas from 12.01 - 16.00 hours. Cattle preferred grasslands only from 06.01 to 10.00 hours. For other times of the day they either avoided these, or showed a very weak preference. Sheep selected shaded areas for grazing from 06.01 - 10.00 hours and 14.01 - 16.00 hours. Except for these times grasslands were preferred for grazing. Sheep avoided using tree groves for grazing.

Fallow bucks in January (Table 4.6, Fig. 4.6) showed preference for tree groves from 12.01 - 14.00 hours, for shaded areas from 16.01 - 18.00 hours, and for grasslands from 10.01 - 14.00 hours. Does showed a preference for tree groves, from dawn to 14.00 hours, and for grasslands from 12.00 - 16.00 hours, after which shaded areas were preferred.

Resting

Fallow bucks while resting in July used shaded areas, except for 06.01 - 08.00 hours when grasslands were used without any preference (Table 4.5, Fig. 4.5). Does showed a preference for tree groves up to 12.00 hours, whilst resting. They preferred grasslands from 16.00 hours until dusk, when shaded areas and tree groves were avoided.

Cattle avoided to use tree groves for resting, and generally preferred shaded areas. They preferred grasslands only from 06.01 - 08.00, and from 12.01 - 16.00 hours. Sheep preferred to rest in tree groves from 06.01 - 08.00 hours, in shaded areas from 08.01 - 10.00 and from 12.01 - 14.00 hours, and in grassland areas from dawn to 08.00 hours and from 20.01 - 23.00 hours. For other times of the day sheep showed no relationship with habitat type for resting.

In January, fallow bucks whilst resting preferred shaded areas in

Table 4.5 Habitat Preference Index (P_2)
Preference for the use of habitat types for resting in relation to time of day, July 1983.

Timespan	Fallow bucks			Fallow does			Cattle			Sheep		
(GMT)	h1	h2	h3	h1	h2	h3	h1	h2	h3	h1	h2	h3
0300-0600	*	.31	*	.44	-.04	*	-.33	.06	.04	-.24	-.46	.36
0601-0800	*	.15	.00	.19	.11	-.76	-.34	-.05	.18	.22	-.27	.12
0801-1000	*	.31	*	.29	.10	*	*	.11	.08	-.17	.22	-.72
1001-1200	*	.31	*	.24	.04	-.42	.09	.10	-.37	.06	-.04	.01
1201-1400	*	.31	*	-.56	.02	.15	-1.3	-.08	.27	.16	.12	-.70
1401-1600	*	.31	*	-.26	.08	-.02	*	.01	.20	-.24	.05	.03
1601-1800	*	.22	-.21	.00	-.35	.27	-.89	.27	-.68	-.05	.01	.01
1801-2000	*	.31	*	-.20	-.13	.21	-.26	.24	-.10	.03	-.10	.01
2001-2300	*	.31	*	-.63	-.09	.25	-.22	.22	-.64	-.51	-.10	.25

HPI calculated on the basis of data in Appendix 4.5.

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

* No animals resting in the habitat type.

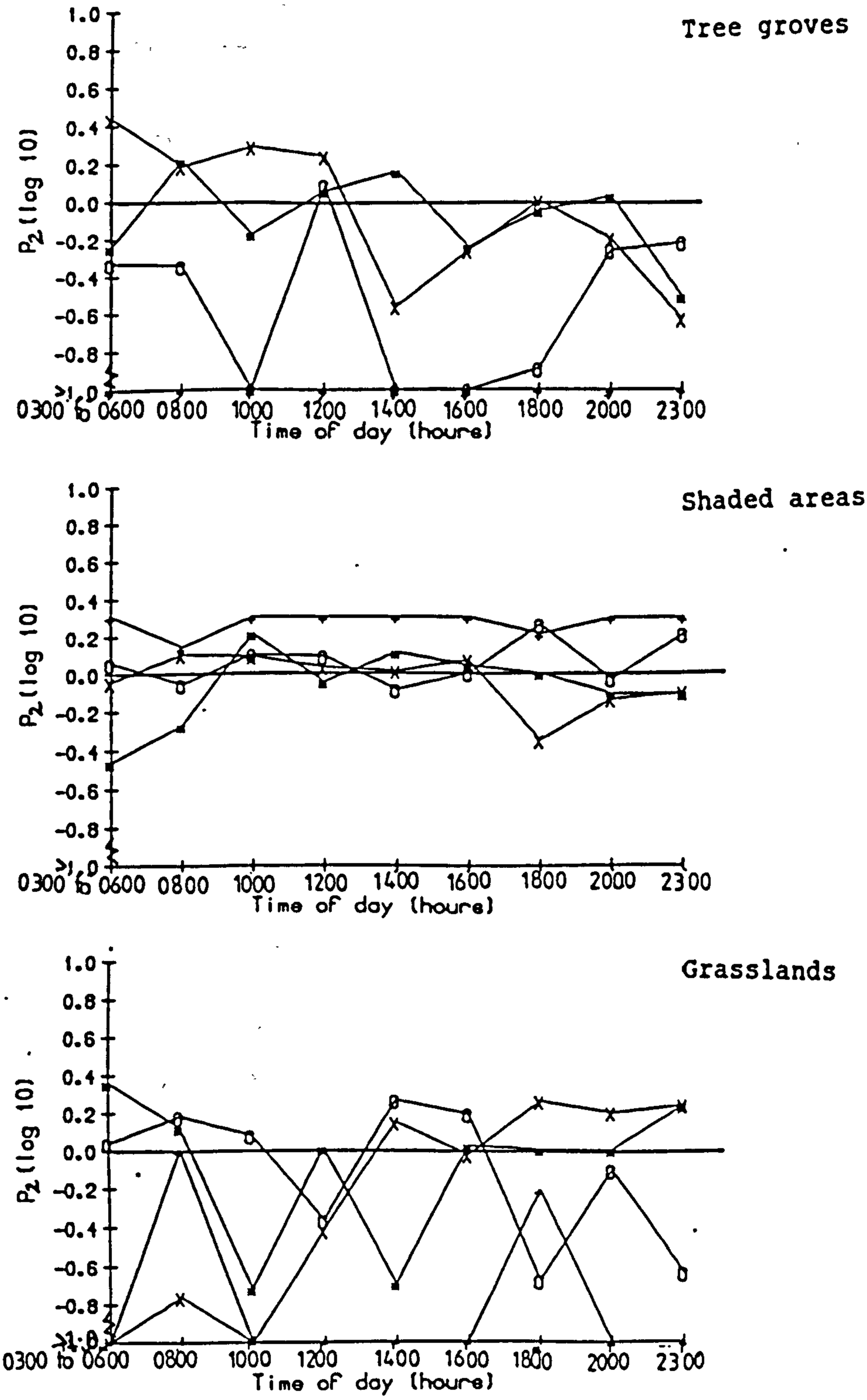


FIG. 4.5 Habitat Preference Index for resting for herbivores in July, in relation to time of day.

Table 4.6 Habitat Preference Index (P_2)
Preference for the use of habitat types for grazing and resting in relation to time of day, January, 1983.

a. Grazing

Time span (GMT)	Bucks			Does		
	h1	h2	h3	h1	h2	h3
0801-1000	.10	.01	-.10	.38	-.09	-.42
1001-1200	-.15	-.17	.23	.08	-.03	-.01
1201-1400	.24	-.80	.27	.28	-.85	.25
1401-1600	-.20	.08	-.03	-.85	-.02	.21
1601-1800	.06	.15	-.62	*	.22	-.20

b. Resting

0801-1000	*	.31	*	*	.31	*
1001-1200	.12	.15	-.77	.32	.08	*
1201-1400	.16	.07	-.34	.35	.05	*
1401-1600	.59	-.82	-.34	.70	*	*
1601-1800	.63	-.54	*	.51	-.14	*

HPI calculated on the basis of data in Appendix 4.6.

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

* Deer not present on the habitat type.

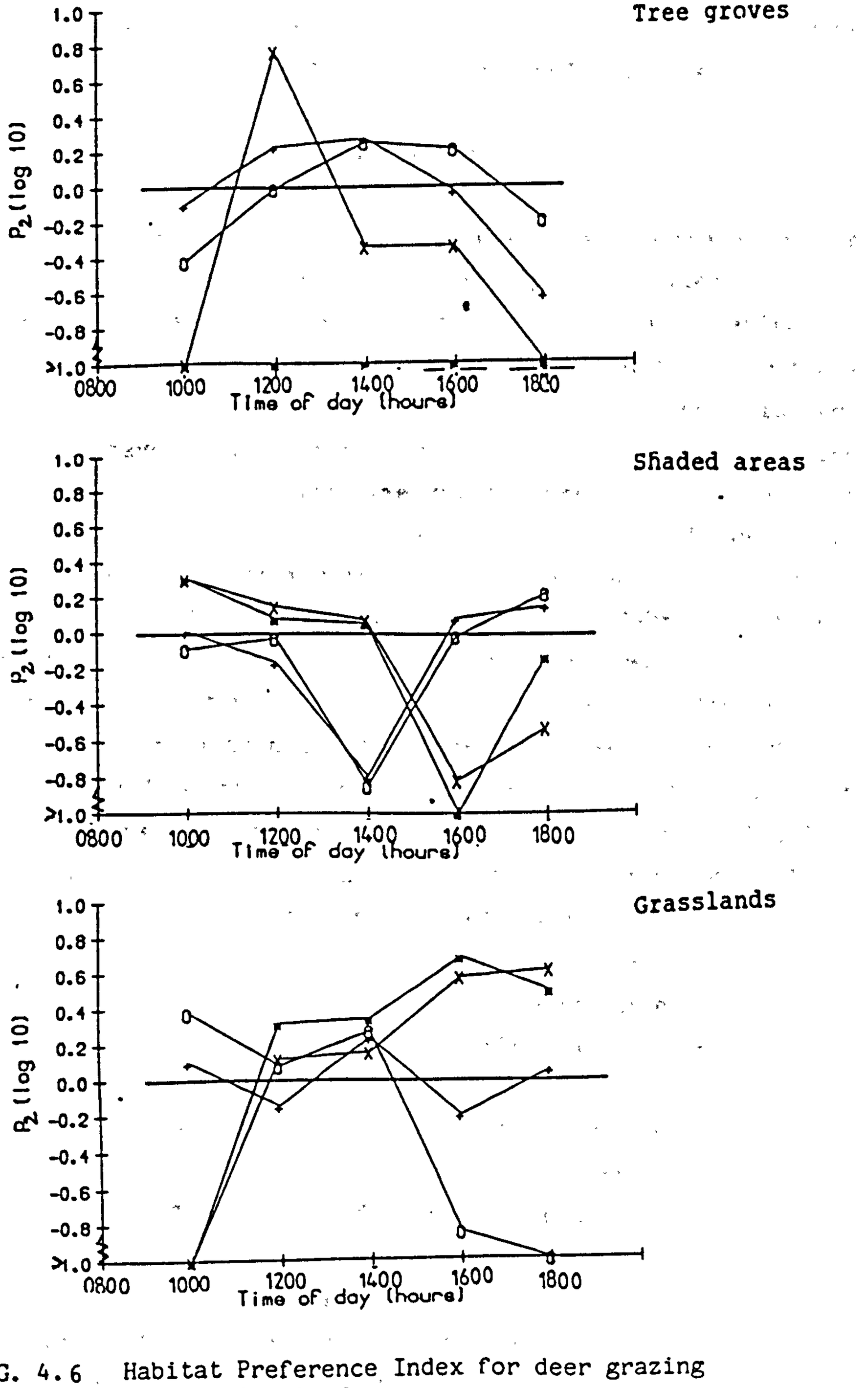


FIG. 4.6 Habitat Preference Index for deer grazing and resting in January, in relation to time of day.

the morning, and tree groves after mid-day (Table 4.6, Fig. 4.6). Fallow does selected shaded areas until 10.00 hours after which they preferred tree groves. Does did not use grasslands for resting.

4.4 DISCUSSION

Both fallow bucks and does showed a seasonal pattern in the percentage of daylight hours spent feeding. During summer (June to August), does spent on an average 51 % of daylight time foraging and bucks spent 48 % of their time feeding. From December to February they both spent on an average about 68 % of their time foraging. Similar patterns have been observed for red deer and hill sheep: red deer grazed for 68 % of daylight time during summer and for 76 % of daylight time during winter (Colquhoun 1971). Clutton-Brock *et al* (1982) reported mature red deer hinds at Island of Rhum grazing for 56 % of day time in July—August as compared to 62 % in February - March. Stags spent only 44 % of their day time grazing in summer and 65 % in winter. Total grazing time during a day in summer in the present study was, however, more than the total grazing time during a day in winter: 9.1 and 9.7 hours for the bucks and does respectively in summer and 6.1 hours both for bucks and does during winter. Red deer in Perthshire grazed for 11.6 hours during the day in summer and for 5.3 hours during the day in winter (Colquhoun 1971). Daylength measures in both the studies, however, differ. Daylength in the present study was taken on the average as 19 hours during the summer, and 9 hours during winter, whereas grazing time in Colquhoun's (1971) study has been calculated on the basis of 17 hours of daytime during summer and 7 hours in winter. The data clearly show the intensity of grazing during winter i.e., 6.1 hours within 9 hours in winter as compared to 9.1 and 9.7 hours out of 19 hours during summer.

Cattle and sheep were present at Hopetoun only from late spring to early autumn. Highest proportions grazing were observed in the autumn (cattle and sheep both spent 81 % of their daylight time grazing in October). Average grazing intensity during summer (June -

August) was 49 % for cattle and 59 % for sheep. Total grazing time during the day in summer was 9.3 hours for cattle, and 11.2 hours for sheep. Hill sheep in Perthshire grazed for 82 % of daylight time in summer (92 % in winter) (Colquhoun 1971). Total grazing time during the day in summer was 13.9 hours (6.4 hours in winter).

More grazing time spent by red deer and hill sheep at Perthshire as compared to the present study could have been an effect of comparatively inferior vegetation of hill pastures as compared with the vegetation at Hopetoun (more forbs and more percent occurrence of grasses like *Lolium* and *Dactylis*). The herbivores have been known to respond to decreasing quality and quantity of vegetation by increasing their food intake and grazing time (Arnold and Dudzinski 1978, Forbes 1982).

Differences in grazing time during summer and winter have also been reported for sheep by Arnold and Dudzinski (1978). They reported that in areas of latitude more than 35°, the gaps between grazing bouts decreased as the day length shortened, until in mid-winter some animals could always be found grazing. This could have been an effect of climatic stress as well. The herbivores tried to capitalize on the higher temperatures during the day and grazed as much as possible to save the heat loss while grazing in colder nights (Moen 1973, Kay and Staines 1981).

Night time grazing may also affect daytime grazing. Arnold and Dudzinski (1978) reported that the proportion of night-time grazing was significantly positively related to total grazing time, and negatively to daylength and latitude. Unfortunately, vegetation structure in the study area was such that the night time observations were not ordinarily possible, so the effect of night time grazing on daytime grazing cannot be determined.

Arnold (in litt., Arnold and Dudzinski 1978) reported that cattle in Australia, as in the present study grazed for less time than the

sheep. This may be due to cattle being more efficient at harvesting their food than sheep, certainly in terms of the energy expenditure in grazing. Hafez *et al* (1975b) suggested that differences in grazing time may also reflect more careful selection of suitable herbage by the livestock.

All the herbivores at Hopetoun showed diurnal patterns in their foraging. However, there were differences between them in precise timing. Fallow does started grazing earlier than the others and the sheep were last to start. By the time cattle and sheep started grazing, the does were already in their first rest period. Fallow does also continued grazing later than others. Very little work has been done on the reasons for different grazing activity in different herbivores. Bueno and Ruckebusch (1978) reported that the onset of grazing in cattle in Toulouse, France was related to sunrise. Diurnal distribution of grazing periods, and not their daily duration, were influenced by the weather. They also reported similar results for sheep grazing in the same areas in France (Bueno and Ruckebusch 1979). Grazing activity was largely confined to the daytime, and the onset of grazing was closely related to sunrise. The sheep grazed during the whole daytime available from November to February. Total grazing time reached its maximum in spring and autumn when most herbage was available. They, however, concluded that "the distribution patterns were more closely related to patterns of daylight than to herbage availability which affected the duration of ingestive behaviour". Another relevant report, however, has been made by Dudzinski and Arnold (1979) about domestic sheep. They reported that though the time sheep started grazing in the morning was influenced by the time of sunrise, the time it stopped was dependent on the amount of grazing done in the previous night, the time of the start of grazing, and the change in humidity during the morning grazing period. They also reported that the start of the afternoon grazing period was influenced by the maximum temp., and the time of its occurrence, and the time of sunset. Stopping of evening grazing depended on the time of start of grazing, time of sunset, and the maximum temperatures. This shows

that the animals' responses to temperature, humidity and day length were all involved in determining daily grazing pattern. It is, therefore, possible that the different species at Hopetoun were influenced by the same factors but that their responses differed. Unfortunately there is no published material available to elucidate this problem further.

All the herbivores at Hopetoun showed diurnal patterns of movement between the available habitats. What were the reasons for these movements ? In July one might predict that movements would occur in relation to the daily pattern of solar radiation, that the animals would graze in the open when the solar radiation was lowest and move into more shaded areas when it was highest. In winter (January) one might predict that movements would occur in such a way as to reduce radiative heat losses and to gain maximum benefit from solar radiation. Thus one might predict that the animals would graze in the open at the times of maximum solar radiation. Do the data collected support these hypotheses ?

Bucks in July mainly used shaded areas both for grazing and resting. Does, however, used grasslands in the afternoon when the solar radiation effect was minimal.

Sheep closely followed this pattern on a day in July. Early morning (up to 06.00 hours) they spent grazing or resting in grasslands, after which they preferred shaded areas. Only 20 % sheep grazed in grassland areas at mid-day (Table 4.1). They preferred grasslands again in the late afternoon when the solar radiation was at its lowest.

Cattle, after an early morning grazing in shaded areas preferred grasslands until mid-morning, and early in the afternoon when more than half the cattle were resting, perhaps as a behavioural adaptation to facilitate evaporative cooling in the warmer daytime temperatures, and perhaps they may initially have sought shade during the higher

radiation levels particularly around mid-day (Low *et al.* 1981). Arnold and Dudzinski (1978) demonstrated that beef cattle in North Queensland increased the use of shaded areas with an increase in temperature. They also reported that temperate breeds of cattle in North Queensland spent upto 11 hours a day in the shade. Provision of shelter tree belts may also improve productivity of cattle as has been shown in treeless Eastern sourveld of South africa (Bishop 1965 in Arnold and Dudzinski 1978).

In winter (January) bucks preferred to use grasslands around mid-day, whereas does preferred grasslands only in the afternoon. They did not use grasslands for resting but used areas with trees (shaded areas and tree groves). Munro (1962, in litt. Arnold and Dudzinski 1978)reported that Scottish Blackface ewes sought shelter [illegible] from strong winds in dips, grassy hollows and behind the rock outcrops. Temperature also affected the sheltering behaviour of the ewes, the degree of sheltering increased with decrease in temperature. Similar results were also reported for mountain sheep in central Wales. Kay and Staines (1981) considered sheltering behaviour of red deer as one of the factors in their survival during winter. Clutton-Brock *et al.* (1982) reported that the location of red deer at Isle of Rhum was strongly influenced by wind speed and direction. Grace and Easterbee (1979) calculated the influence of shelter on heat loss from red deer comparing the extreme conditions of a Scottish Glen, in the woodland and on the exposed hillside. They estimated that heat loss would be twice as much in the exposed position. It may, therefore,be inferred that the preference during winter for areas with shade (shaded areas and tree groves) by fallow in the present study was in response to climatic conditions.

4.5 SUMMARY

1. Three aspects of grazing behaviour were studied - diurnal grazing behaviour, seasonal grazing behaviour and diurnal use of habitat type for grazing or resting.

2. All herbivores showed diurnal patterns in their behaviour: an early morning peak, mid-day rest period and a late afternoon peak, but with slight differences in their timing.
3. Herbivores spent more time grazing than resting.
4. All herbivores grazed for the most part of day in autumn, followed by spring months. The lowest proportions of the day were spent grazing in summer.
5. Deer spent more time of the day grazing in winter than proportions other times of the year.
6. All herbivores showed different patterns of selection for the diurnal use of habitat types for grazing and resting. Does and cattle selected different habitats at different times of the day. Sheep largely selected grasslands for grazing and shaded areas for resting during the day.

5 DIET COMPOSITION

5. DIET COMPOSITION

5.1 INTRODUCTION

It has often been demonstrated that herbivores sharing the same rangeland avoid or reduce competition by selecting different diets (see pages 1-6). Normally such studies have involved extensive, natural or semi natural rangelands where a variety of plant species are available. However, even on intensively managed grasslands with relatively few plant species, differences between herbivores have been recorded (Dudzinski and Arnold 1973; Bryant *et al.* 1979). The rangeland at Hopetoun House falls between the most intensively managed systems and the extensive semi- natural systems.

In this chapter I will examine in detail the plant species selected by each of the herbivores. The primary objective will be to compare the diets of the three species when they share the rangeland but it is also of value to present information for fallow deer throughout the entire year.

5.2 METHODS AVAILABLE

The following methods have been used to evaluate the diets of large herbivores (Van dyne 1968):

i) Direct observations of free ranging or tethered animals to record the relative frequency of different plant species taken. Studies using this method have been made on roe deer (*Capreolus capreolus*) (Kossak 1983), African ungulates (Jarman 1971), kudu (*Tragelaphus strepsiceros*) (Owen-Smith 1979), Impala (*Aepyceros melampus*) (Monro 1979), mule deer (Carpenter *et al.* 1979 , Smith *et al.* 1979), mule deer and domestic sheep (Fullgham *et al.* 1982), mule deer and feral goats (Watts 1982), mule deer and elk (Collins and

Urness 1983), white-tailed deer (Bryant *et al.* 1981), and fallow deer (Jackson 1974).

ii) Methods based on the comparison of sample plots before and after grazing,with diets being estimated by the difference. This has been done both with control plots to correct for plant production during the observations e.g., with cattle (Durham and Kothmann 1977),with bison(*Bison bison*)and cattle (Vuren 1982),with deer,elk and cattle (Miller and Vavra 1982) and also without this correction e.g., with mule deer and cattle (McLean and Willms 1982), mule deer, elk and cattle (Bergman and Hudson 1982; McIntosh and Krausman 1982).

iii) Analysis of extrusa from oesophageal or rumen fistulated animals, for botanical composition. Studies reported are on cattle (Durham and Kothmann 1977), cattle and sheep (Dudzinski and Arnold 1973), cattle, sheep and goats (*Capra hircus*)(Squires 1982(b)), cattle and mule deer (McLean and Willms 1982), cattle, sheep, mule deer, antelope (*Antilocapra americana*) and feral horses (*Equus caballus*) (Vavra and Sneva 1978), sheep, white-tailed deer and Angora and Spanish goats (Bryant *et al.* 1979).

iv) Analysis of stomach contents of dead animals for botanical composition both by macro and micro-histological analyses. Some of the studies reported are on African ungulates (Field 1972), mule deer (Anthony and Smith 1974), white-tailed deer (Arnold and Drawe 1979), reindeer (*Rangifer tarandus*) and caribou (*Rangifer tarandus*)(Klein 1982), red deer (Easterbee 1981), and fallow deer (Jackson 1974).

v) Microhistological analyses of faeces for residues to determine the food plant species taken e.g., on sheep (Alexander *et al.* 1983), Scottish hill sheep (Martin 1955, 1964; Colquhoun

1971; Bullock 1982), Soay sheep (Milner and Gwynne 1974), bighorn sheep (Todd and Hanson 1973; Shanks 1982), cattle (Everitt *et al.* 1981) bison, cattle and sheep (Hansen *et al.* 1973), African ungulates (Stewart 1967; Stewart and Stewart 1971), and red deer (Colquhoun 1971; Charles, McCowan and East 1977; Easterbee 1981),domestic sheep and feral goats (Bullock 1985).

All these methods have certain limitations to their use. Direct observations of feeding animals are usually only possible with domestic or tame/trained individuals. It can also be extremely difficult or even impossible to distinguish between closely related plant species and this problem is particularly severe when dealing with wild animals at the distances at which they can normally be observed. Even with domestic or tame animals grazing on a natural grass sward, identification may be biased towards recording the more easily recognisable species.

Measurements of the loss of vegetation from sample plots (utilization estimates) are also complicated when more than one species of herbivores are present and also by the different growth patterns of grazed and ungrazed vegetation (Mitchell *et al.* 1977).

Problems associated with the use of oesophageally fistulated animals are: contamination by rumen contents, incomplete recoveries of ingested material, high cost and low sampling precision (Van dyne and Heady 1965(a) and (b); Galt *et al.* 1968; Harniss *et al.* 1975). The use of rumen fistulae has the added disadvantages of being limited to large animals, of being more laborious and of additional physiological stress to the animals. The use of fistulae is only suitable for domestic species which can be brought in as and when required for examination.

The main disadvantages of the macro- or microhistological analysis of stomach and intestinal tract analysis is that the animals have to be sacrificed which is usually possible only in large populations of wild animals. Differential digestion may also be a

problem (Norris 1943; Courtright 1959; Bergerud and Russel 1964; Scotter 1966; Vavra and Holechek 1980). Identification of partially digested food items can pose difficulties (Hill 1946; Anderson *et al.* 1965; Westoby *et al.* 1976). Trocar sampling which involves tranquilizing the animal, operating to remove the stomach contents then releasing them back into the wild has been used by Wilson *et al* (1977). Problems associated with the technique are the layering of rumen contents, effectiveness of tranquilization of animals, infection following operation and in extreme cases, the death of the animal.

The disadvantages of pellet analysis have been discussed by Ward (1970), Slater and Jones (1971), Owen (1975), Westoby *et al.* (1976), Scotcher (1979), Smith and Shandruk (1979), Sanders *et al.* (1980), Vavra and Holechek (1980), Holechek *et al.* (1982), Samuel and Howard (1983) and McInnis *et al.* (1983). These include sometimes the initial problem of identifying faeces to a specific herbivore when several species occur on an area, the possibility of differential digestion distorting the results, problems of identifying fragments, and the possibility of destruction of fragments from some plant species during the analysis procedure. The method is also very labour intensive.

The advantages associated with the faecal analysis as described by Croker (1959), Ward (1970), Colquhoun (1971), Anthony and Smith (1974), Scotcher (1979), Easterbee (1981), Holechek *et al.* (1982), Monro (1982) include: non-interference with the normal habits of the animals, lack of restriction on animal movements, easy and unlimited sampling, value for animals ranging over mixed plant communities, feasibility for studying secretive or endangered species, and usefulness in comparing the diets of two or more animals at the same time.

Comparison of methods

A number of workers have made comparisons of the results from these different methods to obtain some quantitative estimates of the

errors involved. Oesophageal fistula and faecal material analysis methods were compared while evaluating steer diets by Vavra *et al.* (1978). Total grasses occurred significantly more in faecal samples whereas total forbs were estimated more in oesophageal samples. Individual grass species, however, did not follow a set pattern, some appearing more in faecal samples and some more in oesophageal samples. All forbs were identified at a greater percentage in oesophageal samples. An importance value ranking from the most common to the least common in the diet was, however, similar both in faecal and oesophageal samples. Smith and Shandruk (1979) compared faecal, rumen and utilization methods to ascertain pronghorn antelope diets. The number of plant species identified in faecal samples was less than in rumen samples but more than that recorded by utilization estimates. They also showed that faeces from mule deer fed known diets showed a substantial difference in the amount fed and that indicated by the faecal analysis. McInnis, Vavra and Krueger (1983) compared the oesophageal, rumenal and faecal samples from sheep with the contents of original hand composed mixtures fed to them. Grasses appeared more and forbs less in faecal and rumenal analyses, whereas oesophageal samples were closer to the original feed. They obtained similar results for the sheep grazing a common plant community. They recommended the use of digestibility coefficients for various plant species in different phenological stages, and for different animal species. However, they also showed that results from ranking components of the diet were similar regardless of the source of method.

5.3 METHODS USED

The use of fistulae on the animals was, not possible because of the problems associated with fistulation (page 93). The semi-wild nature of the fallow deer and free-ranging aspect of the cattle and sheep on a mixed sward type of vegetation made it difficult to recognise the plant species being grazed by the animals. Utilization estimates were also not applicable because of the presence of three

species of herbivores. Rumen content analyses were not possible as it was not feasible to sacrifice the animals.

Faecal pellet analysis presented the only possible method under the circumstances. Although it has been shown to have its drawbacks it nevertheless remains one of the most suitable methods available for studies such as the present one which involve the simultaneous comparisons of several species of herbivores.

I collected faecal samples for each kind of herbivore including separate samples for fallow bucks and does every month from September 1982 to November 1983. The samples were collected as follows, on each sampling day, 3 times a month;

Fallow bucks: 5 pellets from each of 6 individual bucks
Fallow does : 5 pellets from each of 15 individual does
Sheep : 5 pellets from each of 40 individual sheep
Cattle : 2 g dung from each of 20 individual cow pies

To be certain of the identity of the faecal pellets, individual animals were followed discreetly until they voided.

As soon as possible, after faecal collection, the samples were deep frozen at -20 °C. All 3 samples collected in a month were pooled to make one comprehensive sample. I followed the method of Sparks and Malechek (1968) as modified by Hansen *et al*. (undated manuscript) to analyse the faecal pellet samples. Composite faecal samples were oven dried at a temperature of 100 °C for 24 hours and ground in an ultra centrifugal mill using a 1.00 mm screen. The milled samples were treated with common household bleach (active constituent, sodium hypochlorite) 1/6 th strength, for 10-20 minutes to clear the samples. Hertzwig's solution [chloral hydrate 500 g, water 300 ml, glycerol 110 ml, conc. HCl 36 ml] was also tested but it did not give better results than the bleach. The sample was then washed under tap water using a 0.25 mm sieve to wash away the tiny unidentifiable fragments.

Four slides were made per sample using Hoyer's medium [Chloral hydrate 200 g, gum acacia 30 g, glycerol 20 ml, water 50 ml] as a mounting medium. The slides were oven dried at a temperature of 45 °C for 36 hours.

Reference slide collection

I collected all the plant species occurring in the area, including broad leaved and coniferous trees, to make a reference collection to enable identification of the material in the slides of faecal material (photomicrographs, Appendix 5.4). The procedure described for making slides of faecal pellet samples was followed.

Slides of faecal material were examined under a binocular microscope at x125 magnification. The plant fragments were identified systematically. A minimum of 50 identifiable fragments was recorded for each slide. Identification was, however, done by microscopic fields i.e., all the identifiable fragments in a microscopic field were identified, thus the number of total fragments identified on a slide could be more than 50. Only those fragments that were recognised as epidermal tissue were recorded as positive evidence of a plant species on the slide.

Sample size

To decide on the number of slides to be studied for each sample I made 5 slides from the rectal samples of a buck (picked up at random) and identified 50 fragments on each of the 5 slides. I used the number of grass fragments identified, as a test case to find out the variance using the following formula to determine sampling intensity (Snedecor and Cochran 1967; De Vos and Mosby 1969).

$$n = \frac{s^2\ t^2}{d^2}$$

whereas n = number of samples required
s = standard deviation
t = normal deviate at confidence limit level at given degrees of freedom
d = margin of error (arithmatic means times designated accuracy)

In this case:

t = confidence limit taken as 0.05 level
d = designated accuracy = 10 % times $\bar{x}$

Percentage of grasses in the 5 slides was: 58, 50, 48, 52 and 54. n was calculated as 4.0. Subjecting the percent figures to Arc sine transformation, resulted in an n = 1.75. To be on the safe side I decided to use 4 slides for each sample.

Rumen and rectal samples

In addition to faecal pellets, the entire digestive systems were available from 12 does and 2 bucks in the autumn of 1982 and 8 bucks and 2 yearling males in late summer of 1983, as a result of a periodic culling programme. This, therefore, offered the opportunity to compare faecal material from the rectum with rumen contents to determine the possible errors from the faecal analysis. Rumenal contents were spread on plastic trays (45 x 15 cm) and 12 random sub-samples were collected to make one comprehensive sample of about 800 ml, from each of the 24 rumens. At least 30 pellets were collected from each of the rectums. Specimens were preserved in formal acetylalcohol [formaldehyde (5 %), 12.5 ml; ethyl alcohol (70 %), 225 ml, and acetic acid (5 %), 12.5 ml]. The same procedure as described for the faecal pellets analysis, was followed for the analysis of rumenal and rectal contents analysis.

Very little difference in epidermal structures was noticed between different species of a genus, so I identified them as the

genus only e.g., *Agrostis tenuis* and *A. stolonifera* were identified as *Agrostis* spp., and three species of *Poa* viz., *Poa annua*, *P. pratensis* and *P.* trivialis) as *Poa* spp. *Ranunculus ficaria* and *R. repens* were also classed as *Ranunculus* spp. though *R. ficaria* was present on the range only for one month, i.e., May 1983.

I made two corrections while identifying plant fragments following the procedure used by Holechek and Gross (1982):

i) While identifying species such as *Ranunculus repens* and *Rubus* spp. which have epidermal hairs, I recorded the presence very cautiously i.e., only when the hairs were attached to epidermal fragments, even if it was very tiny. The presence of hairs was, however, taken as a positive proof of the presence of the plant, thus recording one fragment in one field irrespective of number of hairs in that particular field.

ii) Moss fragmented into very small pieces and each was identifiable as moss. I discarded all the fragments below a certain size (less than 2.0 cm measured on the scale fixed in the eye piece of the microscope) and identified the fragments of the size larger than that.

Broadleaved trees were not identified by individual species but classed as broadleaved tree species.

Dietary overlap

I determined the dietary overlap between the herbivores by calculating a similarity index following Anthony and Smith (1977). Since data on the dietary selection are percentages, the index of overlap for a particular food plant species selected by a pair of herbivorous species was the lesser of the two percentages. For example, if the buck diet contained 25.5 % *Lolium perenne* and that of sheep 18.9 % or vice versa, then the overlap, Y_i on *Lolium perenne*

would be 18.9 %. The total overlap in herbivore diets for a particular month was calculated as the sum of overlaps, Y_i ,

$$\sum_{i=1}^{n} Y_i ,$$

for each individual plant species consumed during that month where n equals the total number of plant species consumed.

Diversity of plants in the diet

It is possible that the herbivores differed in the width of their diets, that is that they showed differing levels of specialisation. To examine this possibility I calculated the diversity of plants in the diets of herbivores by Shannon-Weaver function (H) (Southwood 1978) as follows:

$$H = -\sum_{i=1}^{ST} P_i \log_e P_i$$

where P_i = the proportion of plant species i in the diet
ST = Total species in the diet.

Rank correlation

To obtain a clear picture of the order or priority of each forage species in the diet and to compare the order of priority in each of the herbivore groups, I calculated Kendall's Rank Correlation co-efficients τ (Siegel 1956).

5.4 RESULTS

5.4.1 Comparison of Rumenal and Rectal Faecal Pellet Samples from Culled Deer

Overall there was no significant difference in the number of species identified in the rumen and rectum for both bucks and does (Table 5.1, below).

TABLE 5.1: Number of plant species/groups identified in the rumenal and rectal faecal samples, obtained from the culled deer.

	Bucks		Does	
	Rumen	Rectum	Rumen	Rectum
Total number of species	35	32	35	36
Grasses	17	16	13	13
Forbs	13	12	17	18

Full data sets giving details of all plant species recorded for each animal examined are given in Appendix 5.1 and 5.2. For most species there was no significant difference in their occurrence when comparing the rumen and rectal contents (Table 5.2). The exceptions are *Cynosurus cristatus* which was recorded significantly more frequently in the rumens of both bucks and does, *Ranunculus repens* which occurred significantly more frequently in rectal samples of does, and broad leaved trees which appeared significantly more frequently in the buck rumens. Contrary to the commonly reported result, total grasses were recorded significantly more frequently in the rumens than in the rectal samples of does, but not of bucks, and total forbs appeared significantly more frequently in the rectal samples.

TABLE 5.2: Comparison of microhistological diet analyses results on rumen and rectal faecal pellet contents. Wilcoxon's matched pair test.£

Plant species/group	Significance level and direction	
	Bucks	Does
1. *Agrostis* spp.	n.s.	n.s.
2. *Anthoxanthum odoratum*	n.s.	n.s.
3. *Cynosurus cristatus*	.05 Rumen+	.05 Rumen +
4. *Dactylis glomerata*	n.s.	n.s.
5. *Festuca rubra*	n.s.	.05 Rumen+
6. *Holcus lanatus*	n.s.	n.s.
7. *Lolium perenne*	n.s.	n.s.
8. *Phleum pratense*	n.s.	n.s.
9. *Poa* spp.	n.s.	n.s.
10. Total grasses	n.s.	.01 Rumen+
11. *Cirsium vulgare*	n.s.	n.s.
12. *Ranunculus* spp.	.05 Rectum+	.01 Rectum+
13. Other forbs	n.s.	.05 Rectum+
14. *Rubus* spp.	n.s.	n.s.
15. Broadleaved trees	.05 Rumen+	n.s.
16. Oak acorns	n.s.	n.s.
17. *Taxus baccata*	n.s.	n.s.
18. Moss	n.s.	.05 Rectum+

£ Siegel 1956

\+ Number of fragments more in

n.s. = Non significant at 0.05 level

With these few exceptions, this analysis suggests that the use of rumen content analysis would offer no major advantages over the use of faecal pellet analysis.

5.4.2 Analysis of Faecal Pellet Samples

Faecal pellet samples were analysed for fallow bucks and does for all months of the year and for cattle and sheep when they were on the range (see page 12). Although the main purpose of the analysis was to compare the diets of all the herbivores when they shared the range, it is of interest to examine all the data available for the fallow deer, particularly to see if any changes occurred when the other herbivores were removed from the system. The results will be considered according to the main groups of plants eaten viz., grasses, forbs, trees and mosses.

Grasses

For all groups of herbivores and for most months, grasses of various species were the most frequently occurring items of the diet. The proportion of grasses in the diet varied greatly throughout the year, being highest in the summer months. The yearly averages were 61 % both for the cattle and the sheep, 52 % for the bucks and 48 % for the does (Table 5.3). Sheep and cattle consistently ate more grasses than bucks and does, and in most months the difference was statistically significant (Fig. 5.A, Appendix 5.3.1). The proportions of grasses taken by does was less than that by bucks except in November 1982 and September, October 1983.

Lolium perenne (ryegrass). For all months of the year *Lolium* was the most frequently occurring grass in the diets of all the herbivores (Table 5.3). The yearly average for sheep was 21 %, for cattle 16.5 %, for bucks and does 14 % each. Sheep took significantly more *Lolium* than all the other herbivores in October 1982, June and

Table 5.3 Overall average*of plant species/groups, percent consumed by the herbivores.

Plant species/group	Bucks*	Does*	Cattle	Sheep
Agrostis spp.	7.2	4.9	7.0	4.4
Alopecurus pratensis	0.3	0.5	2.6	1.2
Anthoxanthum odoratum	1.2	0.7	2.2	2.6
Arrhenatherum elatius	0.8	2.5	2.0	2.0
Cynosurus cristatus	4.7	4.1	4.7	4.7
Dactylis glomerata	3.0	2.8	1.9	2.2
Deschampsia cespitosa	3.3	0.9	0.8	0.7
Festuca rubra	12.8	9.8	8.5	15.8
Holcus lanatus	1.9	1.9	7.6	1.9
Lolium perenne	14.4	14.4	16.5	21.4
Phleum pratense	1.8	3.5	3.8	2.0
Poa spp.	1.1	1.4	2.3	1.6
Rushes	0.0	0.1	0.6	0.5
Total grasses	52.5	47.5	60.6	61.0
Cirsium vulgare	1.0	1.4	0.2	0.2
Prunella vulgare	2.5	2.4	1.9	1.9
Ranunculus spp.	6.7	7.7	4.5	5.6
Taraxacum officinale	3.2	3.0	3.3	3.5
Trifolium repens	2.9	2.0	0.4	2.5
Urtica dioica	1.6	2.1	0.4	0.3
Other species	1.4	3.4	3.2	3.0
Total forbs	19.3	22.0	13.7	17.1
Rubus spp.	1.1	0	0	0
Broad leaved trees	9.5	9.9	9.2	6.4
Taxus baccata	5.9	8.4	2.4	1.0
Mast	3.2	5.3	0.1	0
Moss	8.5	6.9	14.0	14.6

* Calculated for the months all the animals were on the range i.e.,excluding months - December 82 to March 83.

July 1983. Bucks consumed significantly more *Lolium* than does in October, 1983 and more than does and cattle in October 1982 (Fig. 5.E, Appendix 5.3.2). Does ate more *Lolium* than did bucks in November 1982 and January 1982.

Festuca rubra (red fescue). Fescue was the next most important grass in the diet of all the herbivores (Table 5.3). Yearly averages were 16 % for sheep, 13 % for bucks, 10 % for does and 9 % for cattle Sheep consumed significantly more *Festuca* than did does and cattle in October 1982, May, June and July 1983,more than cattle in August and September 1983 and bucks in June and July 1983 (Fig. 5.F, Appendix 5.3.3). Bucks ate significantly more *Festuca* than does in October 1982, May and November 1983, whereas the does consumed more only in November 1982. During the winter months, the diet of bucks contained significantly more *Festuca* than that of does in February and March 1983.

Agrostis spp. including *A.tenuis and A.stolonifera* (bent grass). *Agrostis* was more important for bucks and cattle (7 % of the diet, averaged over all months) than it was for the does and the sheep (4.9 and 4.4 % respectively) (Table 5.3). Bucks ate significantly more *Agrostis* than all the other herbivores in May, and for all except for the cattle in June 1983 (Fig. 5.G, Appendix 5.3.4). Intake by cattle was significantly more than does and sheep in October 1982, June and August 1983, and bucks in August 1983. Maximum proportions of *Agrostis* were taken by cattle in August (10.8 %) and September 1983 (11.5 %)).

Cynosurus cristatus (crested dogtail). Yearly averages in the diets of bucks, cattle and sheep were 4.7 % and of does 4.1 % (Table 5.3). Cattle consumed significantly more *Cynosurus* than did the bucks and does in July and August and than sheep in August 1983. (Fig.5.H, Appendix 5.3.5). Sheep ate more *Cynosurus* than does in July 1983. Maximum intake was in the later part of the year; by cattle in July and August (7.5 %), by sheep in July (7.2 %), and by bucks in November

1983 (7.7 %).

Holcus lanatus (Yorkshire fog) was important only for cattle with a yearly average of 7.6 % compared with 1.9 % for the other herbivores (Table 5.3). Cattle ate significantly more *Holcus* than did bucks, does and sheep in October 1982, June, July, August and September 1983 (Fig. 5.I, Appendix 5.3.6). *Holcus* proportions in the diet of bucks were significantly more than those in the diets of does and sheep, in July 1983, whereas the does diets contained more *Holcus* than buck diets in December 1982 and October 1983. Maximum intake (14 %) was by cattle in September 1983. Bucks and does consumed 9.1 % and 10.1 % *Holcus* only in July and October 1983 respectively. In all other months, the consumption by the bucks, does and sheep was less than 4%.

Dactylis glomerata (cocksfoot) was equally important for bucks and does with yearly averages of 3.0 % and 2.8 % respectively as compared to sheep (2.2 %) and cattle (1.9 %) (Table 5.3). Intake by bucks in May 1983 was significantly more than the other herbivores (Fig.5.J, Appendix 5.3.7). Does ate more *Dactylis* than sheep in April, than bucks and cattle in November 1983. Maximum consumption (5.7 %) was by bucks in June 1983.

Phleum pratense (timothy). Cattle and does, over all months, consumed more *Phleum* than did the sheep and the bucks (3.8 and 3.5 % as against 2.0 and 1.8 % respectively) (Table 5.3). Cattle ate significantly more *Phleum* than bucks in October 1982, and more than does and sheep in October 1982, June and July 1983 (Fig.5.0, Appendix 5.3.8). Intake by bucks was significantly more than that by does in July, whereas that by does was more than sheep in September 1983, and more than bucks and cattle in September, October and November 1983. Maximum intake (10.1 %) was, however, by does in September 1983.

Deschampsia cespitosa (tufted hair grass) was important only for the bucks who consumed 3.3 %, averaged over all months (Table 5.3). Other herbivores ate less than 1.0 %. Bucks consumed significantly

more *Deschampsia* than did does in September 1982 and July 1983, than sheep in September 1982, May and June 1983 and, more than did cattle in May (Appendix 5.3.9). Does ate significantly more *Deschampsia* than the cattle and sheep in May 1983. The cattle diets contained more *Deschampsia* than the sheep diets in August 1983. Maximum *Deschampsia* in one month (10.7 %) was taken by bucks in October 1983.

Poa spp. (including *P. annua*, *P. pratensis* and *Poa trivialis*) (meadow grass). *Poa* averaged over all months, was more important for cattle (2.3 %) than the other herbivores (bucks 1.1 %, does 1.4 %, and sheep 1.6 %) (Table 5.3). Cattle consumed significantly more meadow grass than bucks in August and November 1983, and more than that by does and sheep in August 1983. Maximum intake (7.4 %) was by cattle in August 1983.

Other grasses in the diet analysis: *Alopecurus pratensis* (Appendix 5.3.10.a) for cattle in July (5 %) and June 1983 (4 %); *Anthoxanthum odoratum* (Appendix 5.3.10.b) for sheep in July and August (4 %); for cattle in August (4 %), and *Arrhenatherum elatius* (Appendix 5.3.10.c) for does in August and September 1983 (7 %), for bucks 5 % in June, for cattle (6 %) in July, and for sheep (4 %) in July 1983.

The rushes, *Juncus effusus* and *Luzula campestris* were found in trace quantities in the diets of bucks and does.

Forbs

Total forbs were the next important group after grasses in the diets of all the herbivores (Table 5.3). Intake by does, over all months, was 22.0 % followed by bucks and sheep (19.5 and 17.1 % respectively). Cattle diets contained 13.7 % forbs. Bucks consumed significantly more forbs than did the other herbivores in June and July, whereas does ate more forbs than all the other herbivores in September, October and November 1983. Significantly more forbs were taken by the cattle only in June 1983 (Fig.5.B, Appendix 5.3.11).

Maximum proportions of forbs were recorded in the diet of bucks (43.2 %) in June 1983. More forbs were taken in early spring than in any other season of the year. Forbs were significantly more in the diets of bucks as compared to that of does in March 1983.

Ranunculus spp. (including *R. ficaria* and *R. repens*) occurred slightly more in the diets of does and bucks (yearly averages of 7.7 % and 6.7 % respectively) as compared to that in the diets of sheep and cattle (5.6 and 4.5 % respectively) (Table 5.3). Bucks consumed significantly more *Ranunculus* than did all other herbivores in June, than cattle in July, October and November 1983, and more than sheep in July (Fig. 5.K, Appendix 5.3.12). Cattle diets contained significantly more *Ranunculus* than those of sheep in June and July 1983, of bucks in October 1982, and of does in June. Does ate significantly more *Ranunculus* than bucks and cattle in September - November 1983, than bucks in December 1982 and than sheep in September 1983. Maximum use of *Ranunculus* by all the herbivores was made in May and June 1983. Does, however, consumed larger amounts (>10 %) in October and November 1983 as well.

Prunella vulgaris (self heal). Intake of *Prunella vulgaris* was roughly the same, at around 2 %, for all species and months (Table 5.3). Bucks ate significantly more *Prunella* than does and sheep in September 1982 and does more than bucks and cattle in November 1983 (Fig. 5.N, Appendix 5.3.13). Maximum proportion recorded was 5.9 % in the diet of bucks in September 1982.

Taraxacum officinale (dandelion) was taken almost equally by all the herbivores (about 3 %) throughout the year (Table 5.3). Significantly more *Taraxacum* was taken by cattle than by does and sheep in June, and by bucks more than sheep and does, respectively in April and June 1983 (Fig. 5.M, Appendix 5.3.14). Does ate more *Taraxacum* than cattle in April 1983. Maximum *Taraxacum*, by all the herbivores, was consumed in the spring months, especially in May 1983.

Trifolium repens (white clover). The yearly averages taken were 2.9 % for bucks, 2.6 % both for does and sheep, and only 0.8 % for cattle (Table 5.3). Significantly more clover was consumed by bucks than by other herbivores in May, and more than by the cattle in July 1983 (Fig. 5.L, Appendix 5.3.15). Does ate more clover than did bucks in October 1983, and cattle in June and November 1983. Sheep diets contained significantly more clover than cattle diets in July and September 1983. Maximum clover intake in one month was by does (10.4 %) in June 1983.

Urtica dioica (stinging nettle) intake, over all months was 2.1 % by the does and 1.6 %, by the bucks (Table 5.3). Cattle and sheep ate very small amounts (0.4 % and 0.3 % respectively). Bucks took significantly more *Urtica* than did does and sheep in September 1982 (Appendix 5.3.16). Diet of does contained significantly more nettle than those of bucks and cattle in October, November 1983, than those of cattle and sheep in July 1983. Cattle ate more nettle than did does in August 1983. Maximum consumption in one month was by does (12.1 %) in November 1983.

Cirsium vulgare (spear thistle), over all months,was consumed mainly by bucks and does (1.0 % and 1.4 % respectively) (Table 5.3). Cattle and sheep diets contained only 0.2 % *Cirsium*. Maximum intake by bucks was 5.4 % in August and that by does (5.3 %) in September 1983 (Appendix 5.3.17).

Other forbs eaten in trace quantities were: *Leontodon autumnalis*, *Achillea millefolium*, *Rumex acetosella*, *Bellis perennis*, *Galium aperine*, *Lotus corniculatus*, *Plantago lanceolata*, *Mentha aquatica*. *Cerastium fontanum*, *Stellaria media* and *Veronica chamaedrys* though present on the range, were not detected in the diets.

Browse

The foliage of broad leaved tree species was recorded in the diets of all the herbivores in all months. Proportions, averaged over

all months, were 9.9 % for does, 9.5 % for bucks, 9.2 % for cattle and 6.3 % for sheep (Table 5.3,). Does consumed significantly more foliage from broad leaved trees than did bucks in September 1982, May and August 1983; than by cattle in October 1982, May, July and August 1983, and than sheep in September, October 1982, May, July and August 1983 (Fig. 5.C, Appendix 5.3.18). Bucks ate significantly more foliage than the other herbivores in September 1983, than cattle and sheep in October 1982 than does and cattle in October 1983 and November 1983 respectively. Intake by sheep was significantly more than bucks and does in April 1983. Maximum proportions in the diets of all the herbivores were recorded in the spring and autumn months (except does). Does also ate large amounts of tree foliage in July and August 1983 (16.0 and 14.8 % respectively).

Taxus baccata (yew) was available only within a small fenced off area (see map,Fig. 2.1). Bucks and does would enter this area freely but cattle and sheep had access only to the perimeter. The yearly average taken by does was 8.4 % and by bucks, 5.9 % (Table 5.3). Cattle and sheep took only 2.4 % and 1.0 % respectively, probably because of the limited access to this food supply. Bucks showed a clear annual pattern of intake, consuming more during winter months than in the summer (Fig. 5.P, Appendix 5.3.19). The pattern for does was less clear and although they took a large proportion of *Taxus* in late winter, they also took large quantities in June and July 1983. These last two months coincide with the fawning season when the does spend a higher proportion of their time in denser cover and this may be the reason for the increased intake of *Taxus*.

Rubus spp. (bramble) were also available mainly to the bucks and does. It was taken by bucks and does and only during the winter months - November 1982 - March 1983 (Fig. 5.Q, Appendix 5.3.20). In all the months, it was taken significantly more by bucks,with an average of 10.6 % over the period September 1982 to March 1983, maximum 18.5 % being taken in February.

Mast (including oak acorns, beach mast, chestnut) was recorded only in the diets of bucks and does in the autumn months, October and November 1982 (Fig. 5.R, Appendix 5.3.21). Autumn 1982, was a good mast year, when the does ate 29 % and 34 % mast in October, November 1982, respectively, significantly more than that taken by the bucks. In November 1983 mast made up only 6.8 % of the diet of bucks and only 1.3 % of the doe diets.

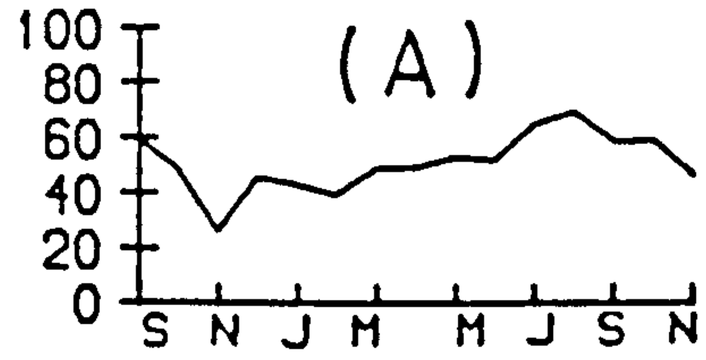
Moss

Only one species of moss (*Phytidielphus squarrosus*) appeared in the diets of the herbivores (Table 5.3). For sheep yearly averages were 14.6 %, 14 % for cattle, 8.5 % for bucks and 6.9 % for does. Intake of moss by sheep was significantly greater than that by bucks,does and cattle in May, June and September 1983, by bucks in April 1983, by does in October 1982 and by bucks and cattle in August 1983 (Fig.5.D, Appendix 5.3.22). Cattle consumed significantly more moss than did bucks in November 1982, June, October and November 1983, and the does in October, November in both the years. More moss occurred in the diets of bucks than that in doe diets in October 1982, 1983, and cattle diets in October 1982. Does ate more moss than the bucks in February, April and June 1983.

Bracken (*Pteridium* sp.) was available to the deer in fenced off areas, but appeared only in 3 diet samples of bucks in trace quantities.

5.4.3 Similarity of Diets

Indices of dietary similarity were computed for all months, when the different herbivores were together on the range (Table 5.4). These indices show the amount of overlap in the diet between any particular pair of herbivores, or more importantly for this study, the degree of difference between the diets. All pairs compared showed substantial overall differences. The greatest difference was between



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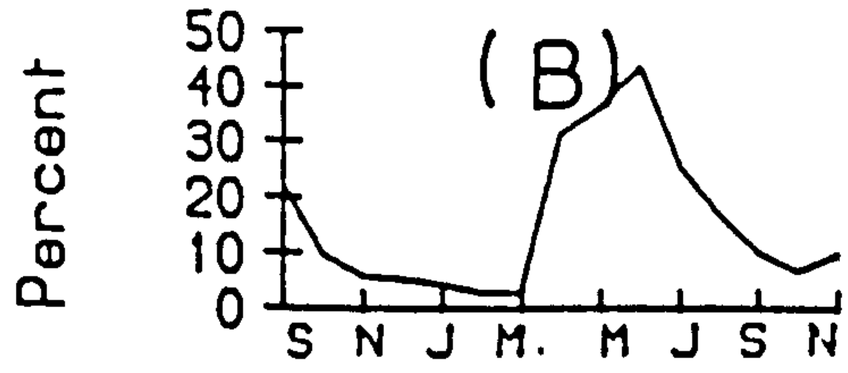

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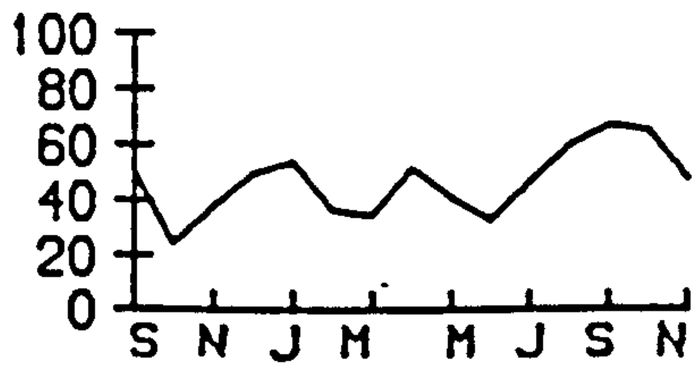

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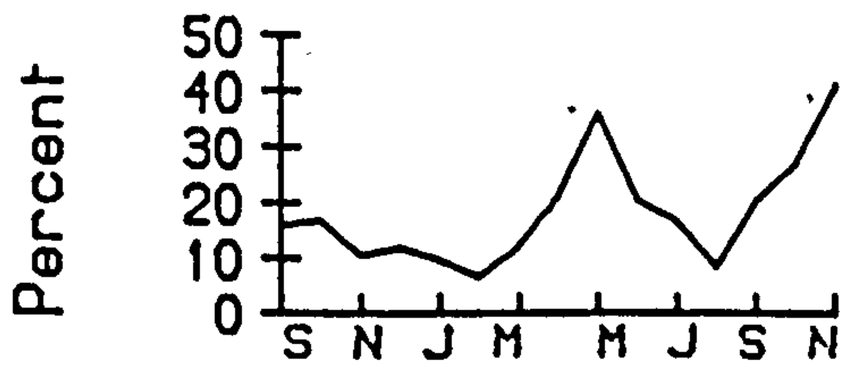

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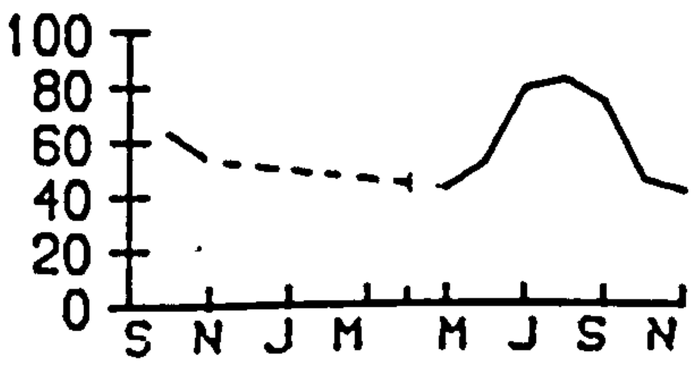

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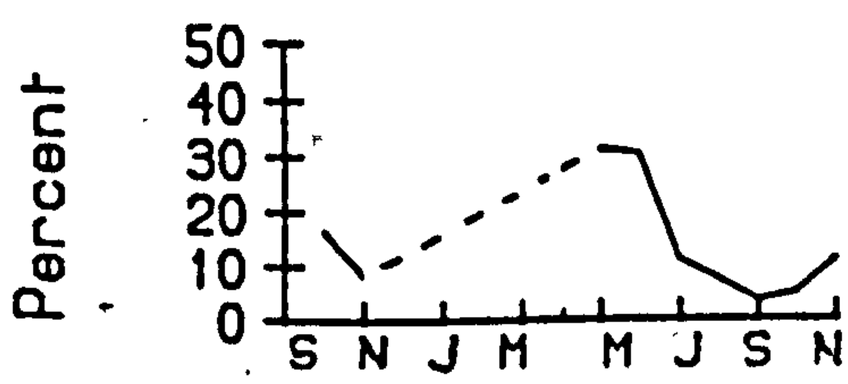

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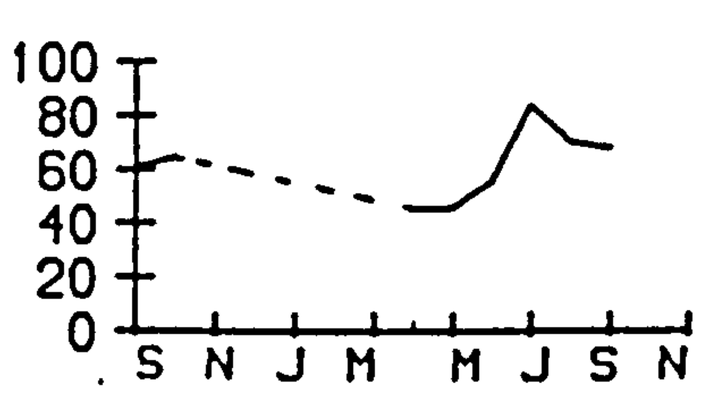
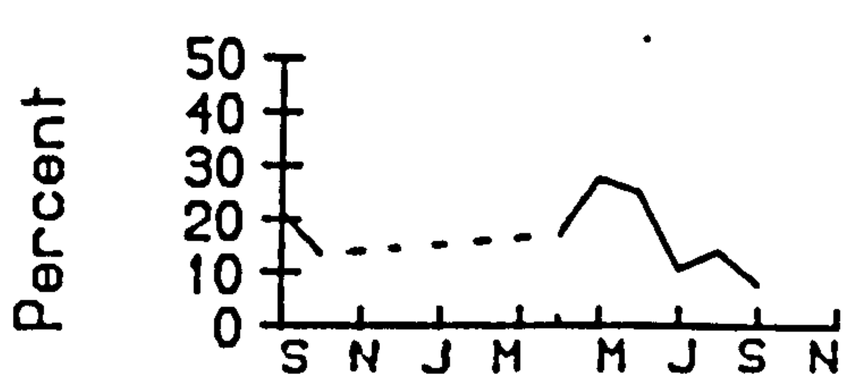
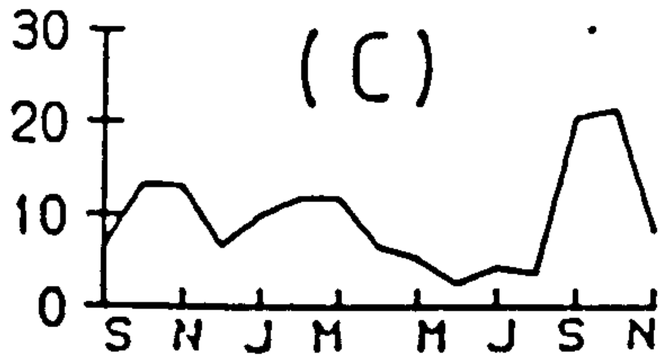


SHEEP



SHEEP

FIG. 5
The proportions of plant species/groups in the diet of herbivores (A) Grasses, (B) Forbs.



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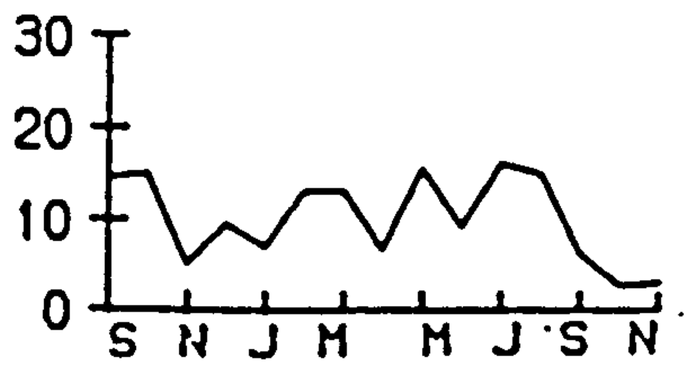

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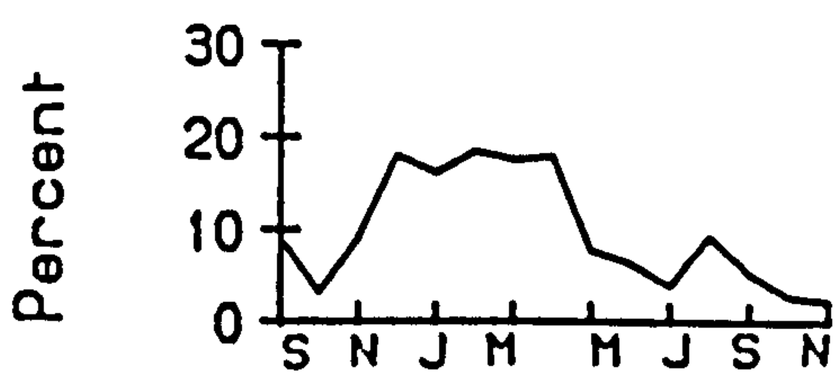

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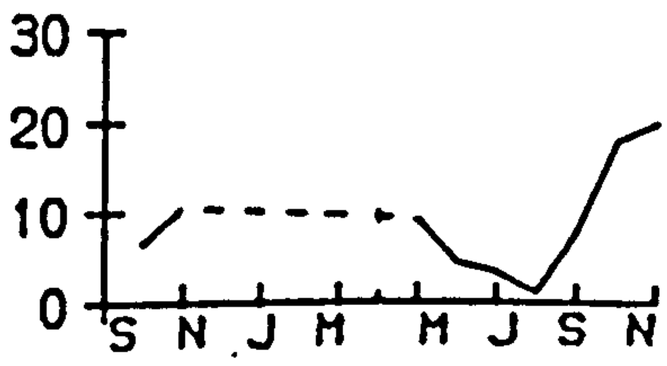

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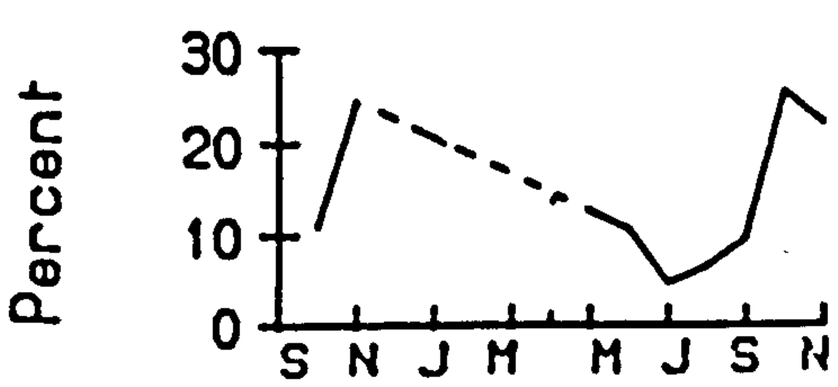

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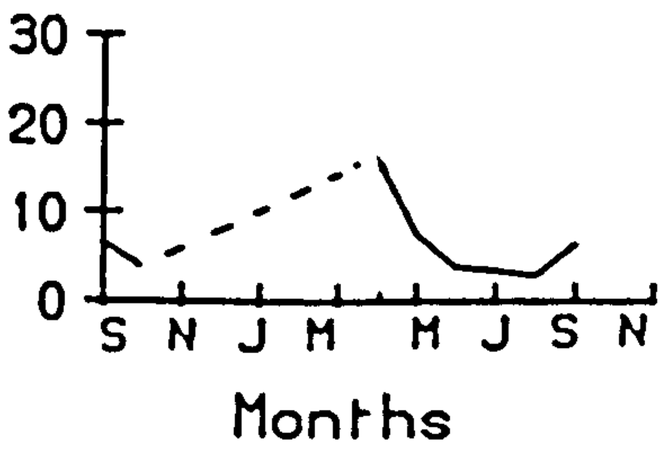

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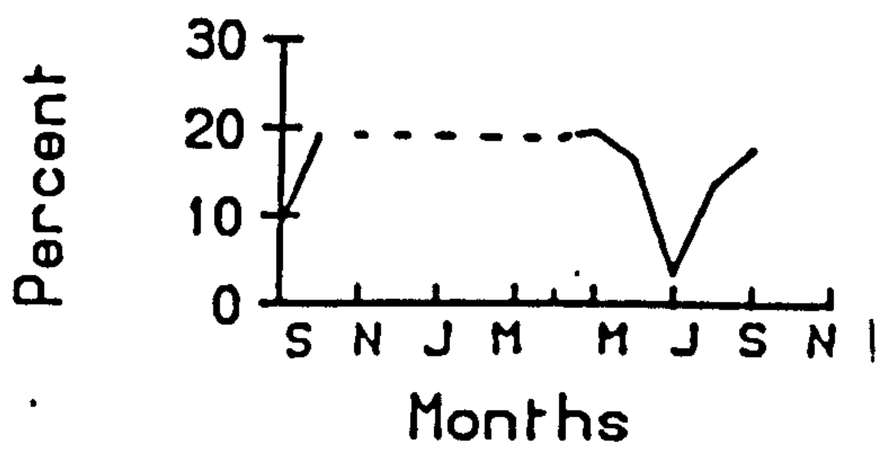
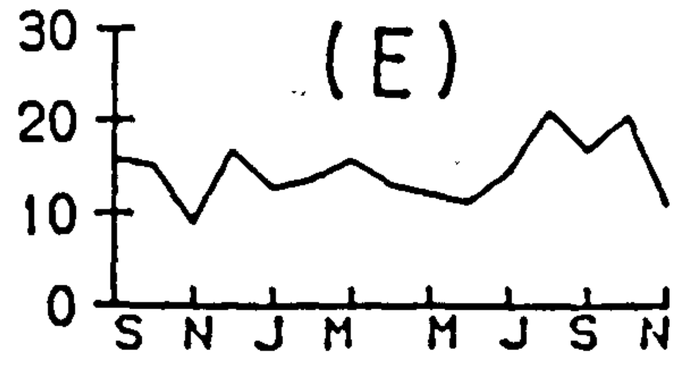
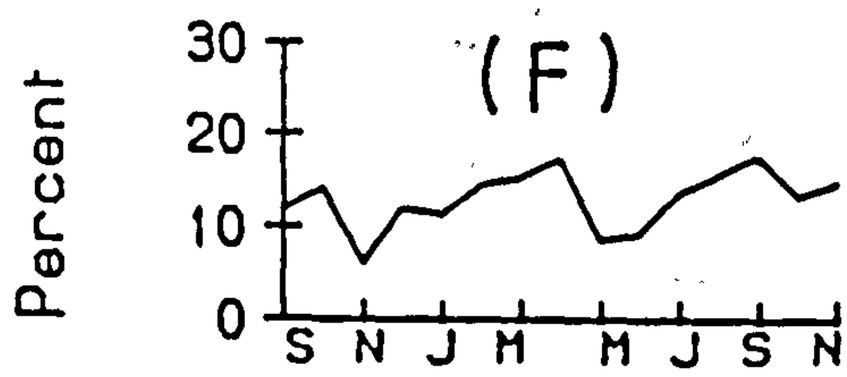
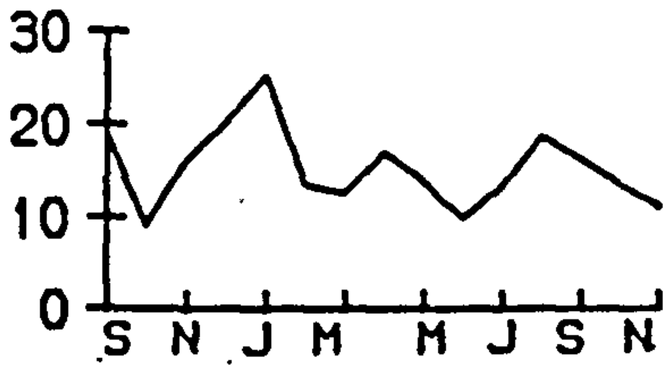


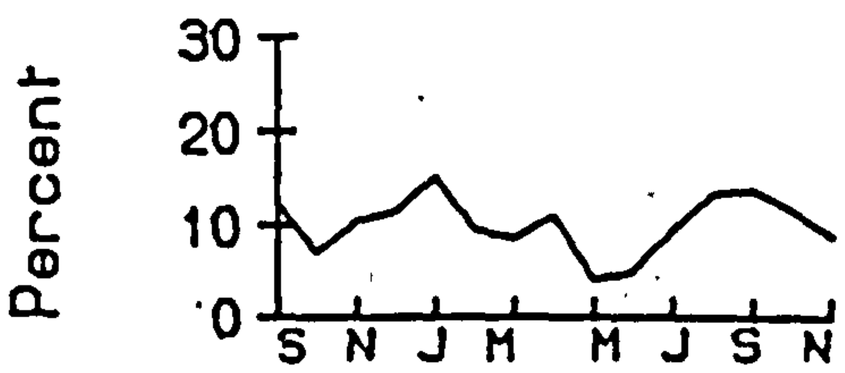
SHEEP

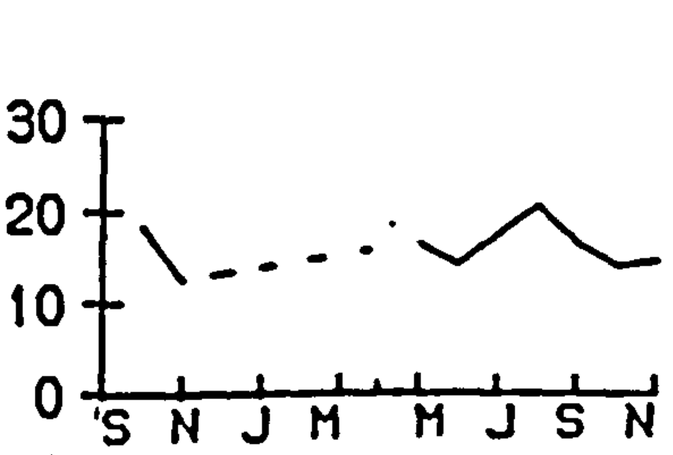
FIG. 5 (continued)
(C) Broad leaved trees, (D) Moss.

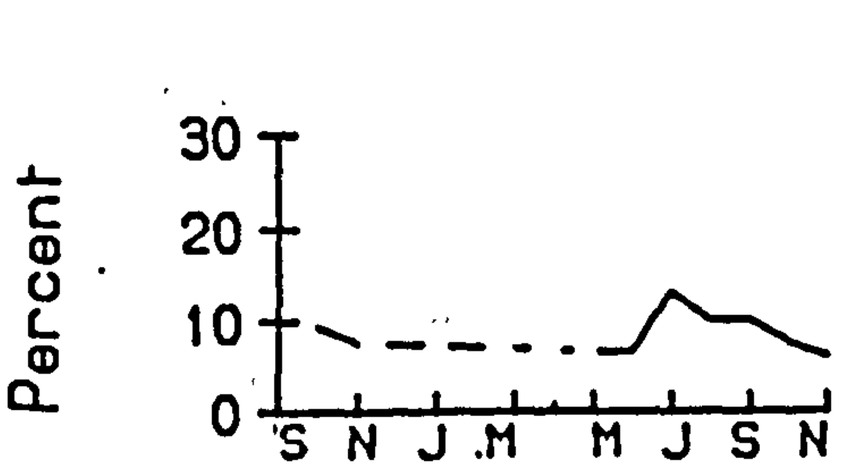












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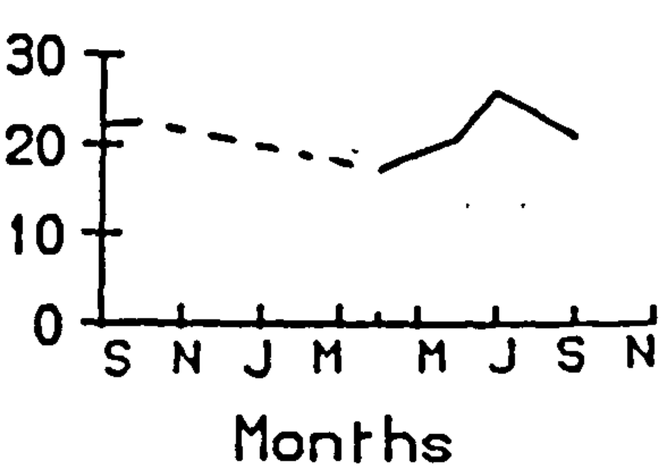


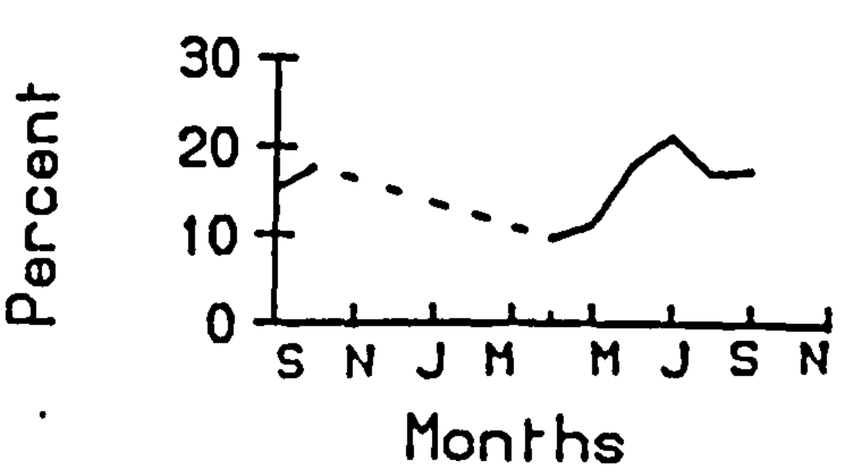
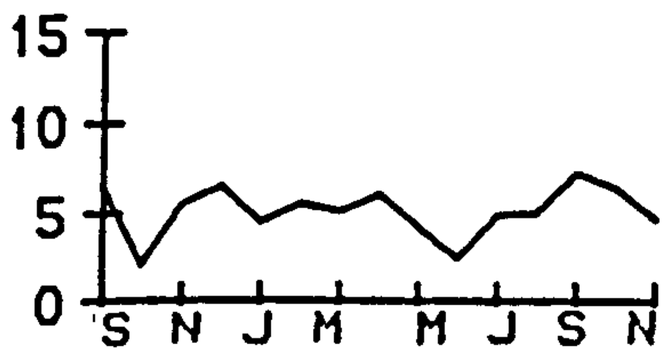
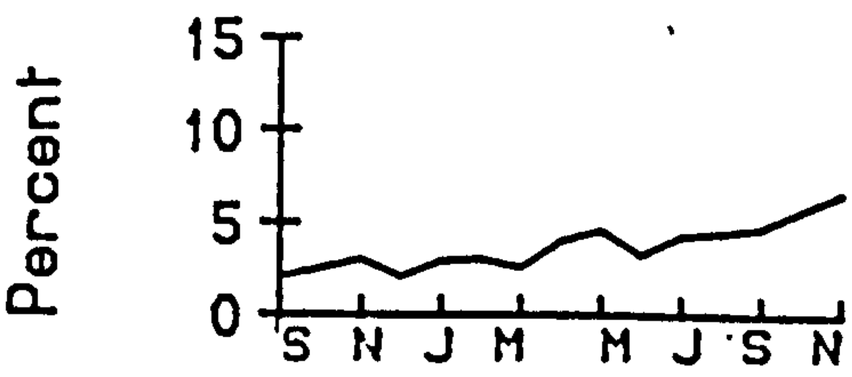
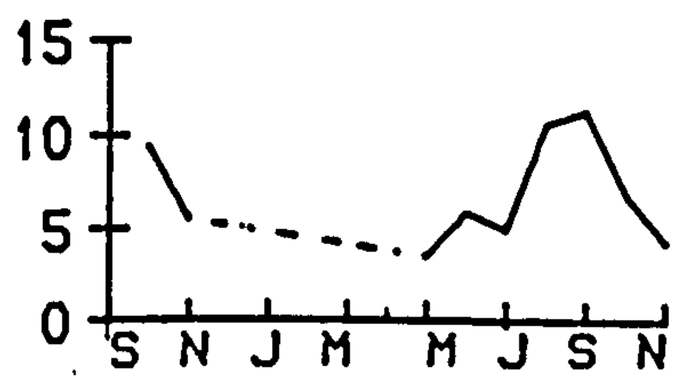


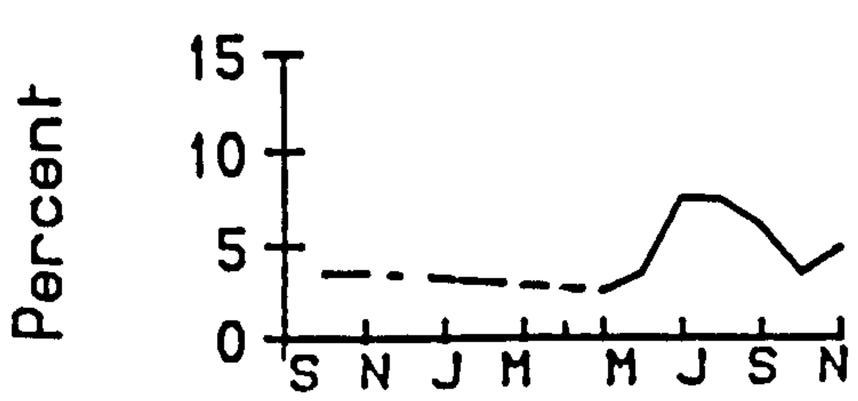
FIG. 5 (Continued)

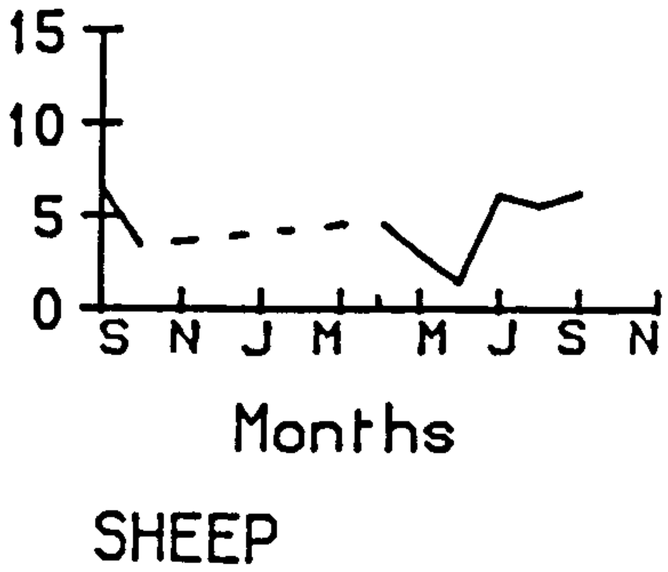
(E) *Lolium perenne*, (F) *Festuca rubra*.











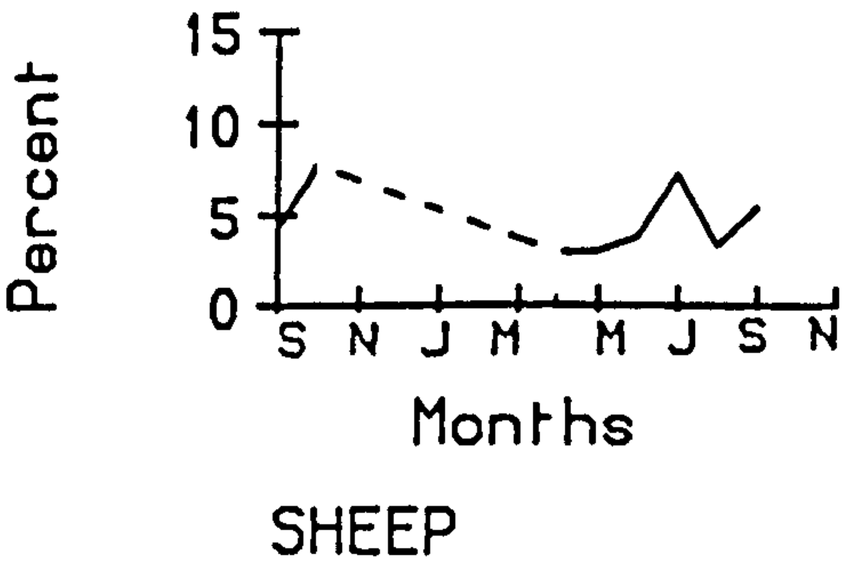
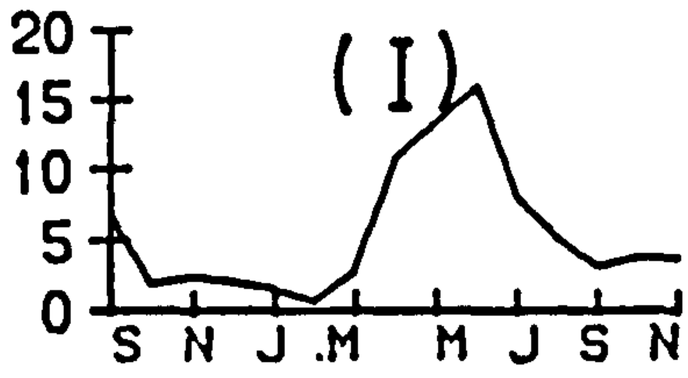
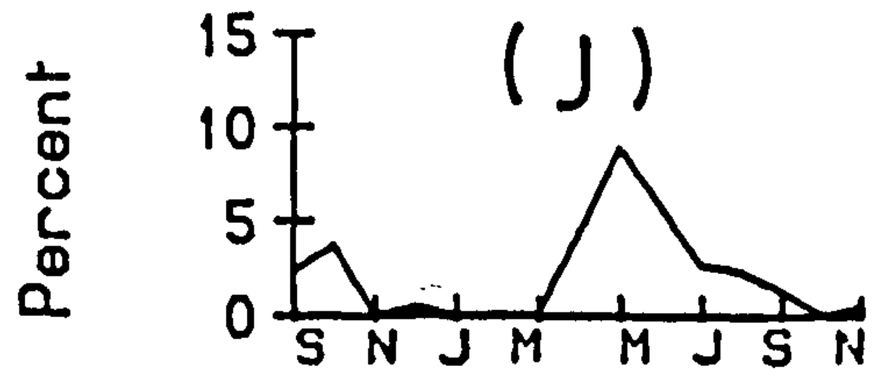


FIG. 5 (Continued)

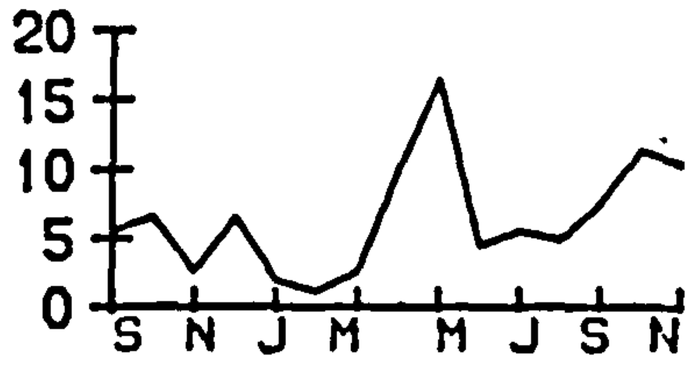
(G) *Agrostis* spp., (H) *Cynosurus cristatus*



BUCKS



BUCKS



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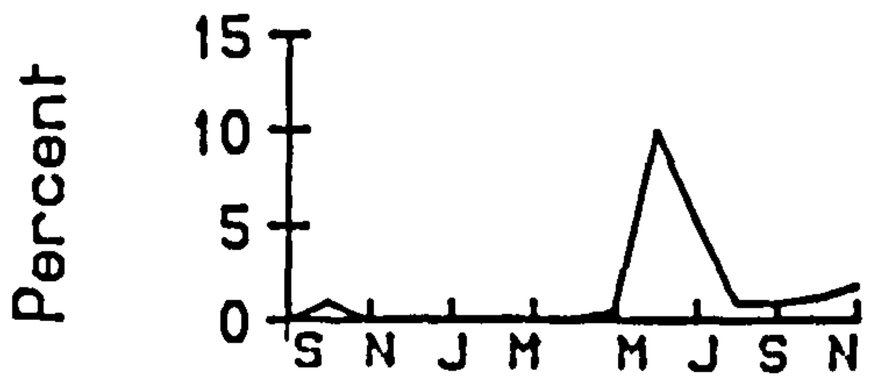

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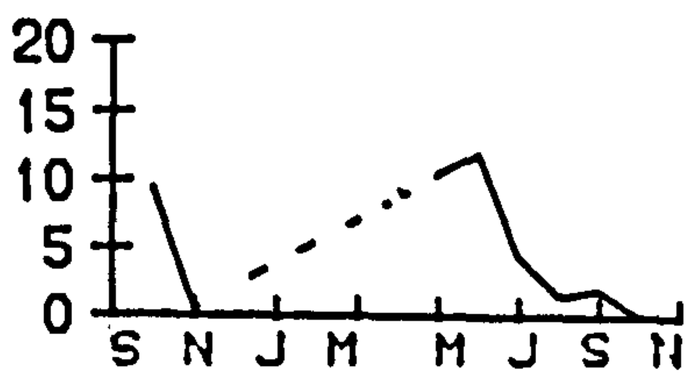

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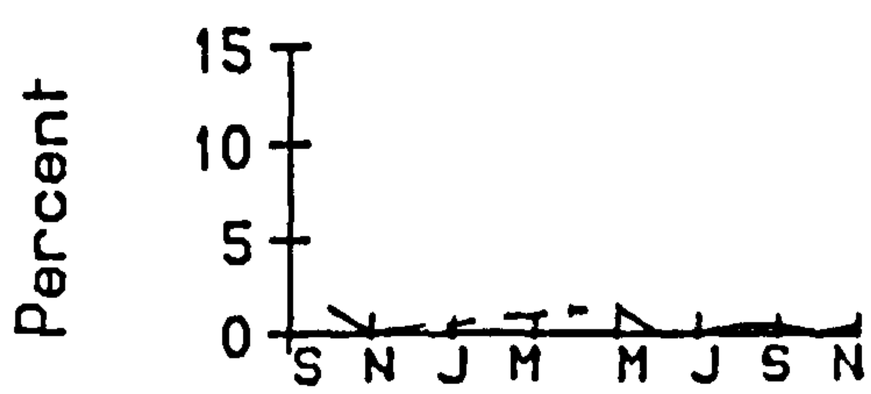

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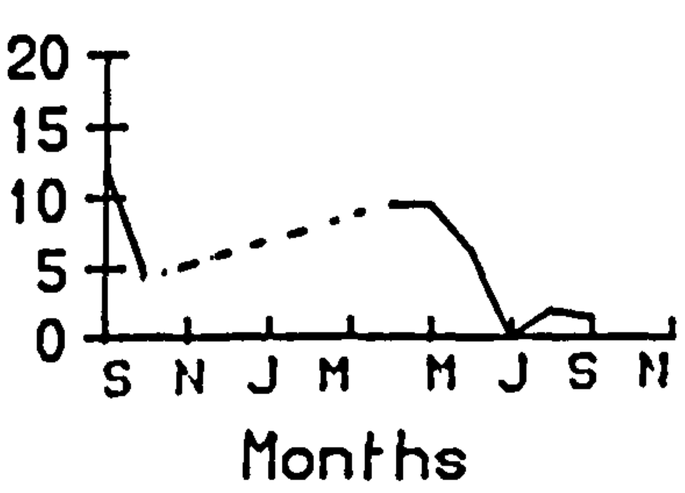
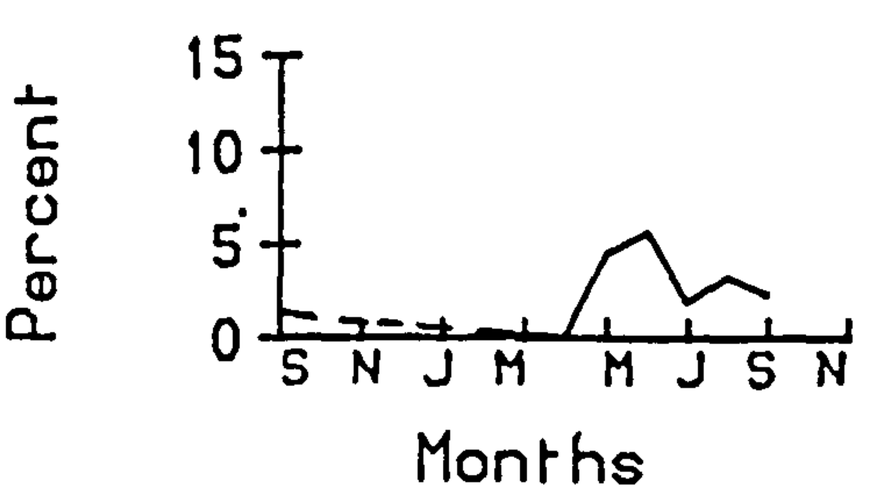


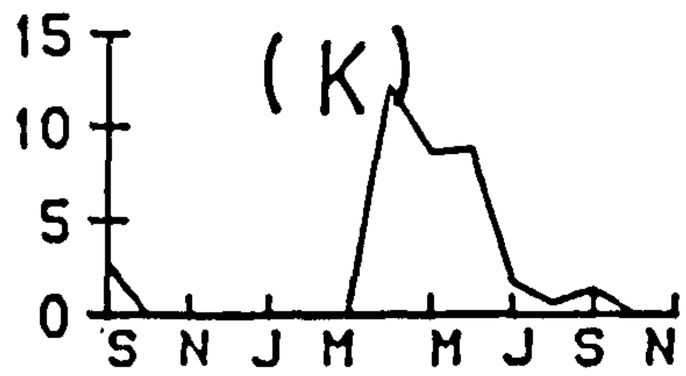
SHEEP

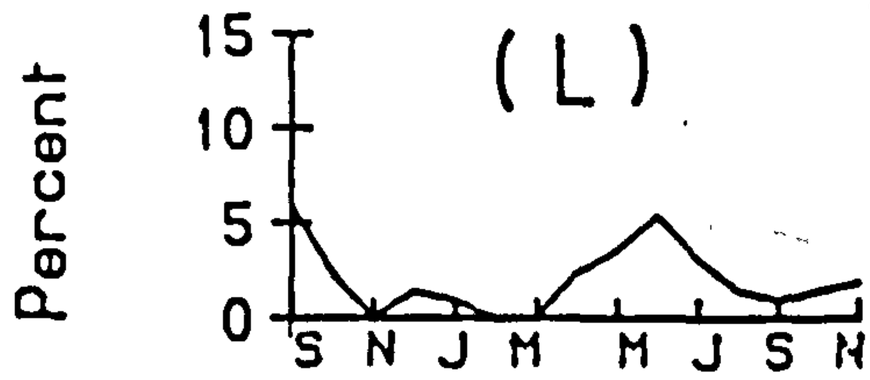


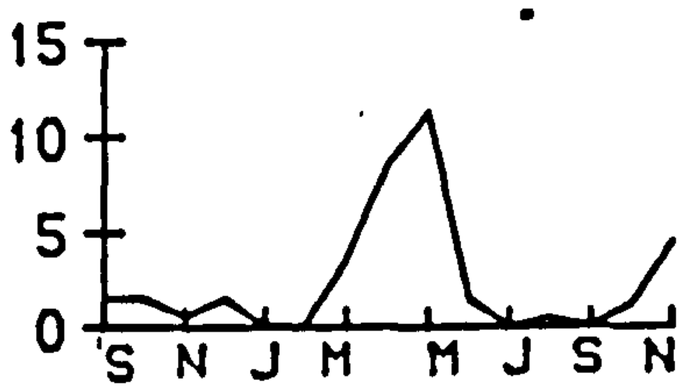
SHEEP

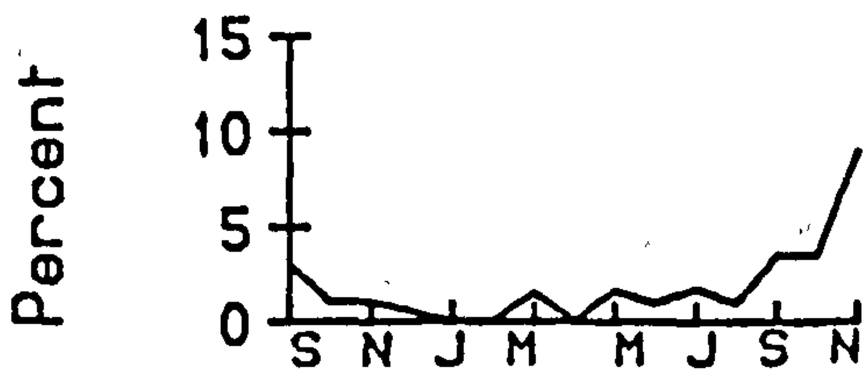
FIG. 5 (Continued)

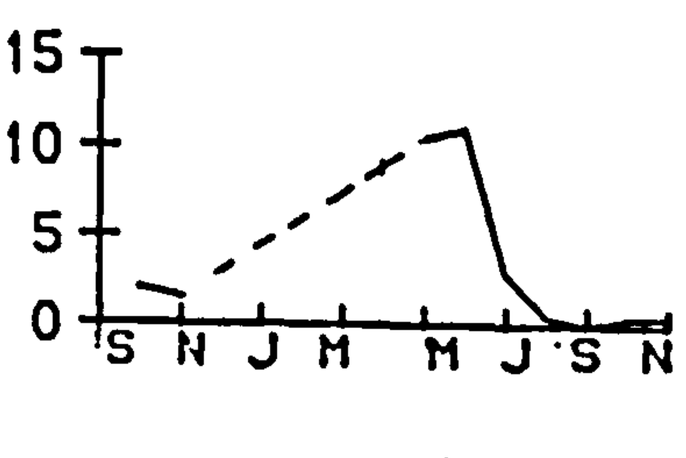
(I) *Holcus lanatus*, (J) *Dactylis glomerata*.











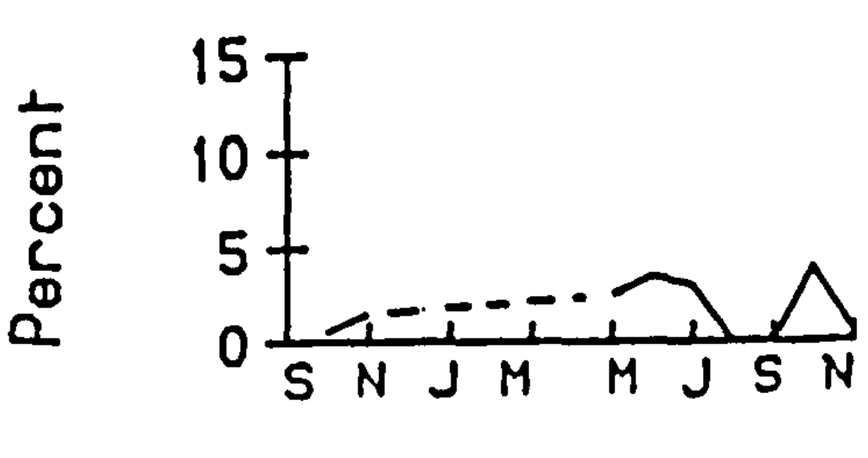
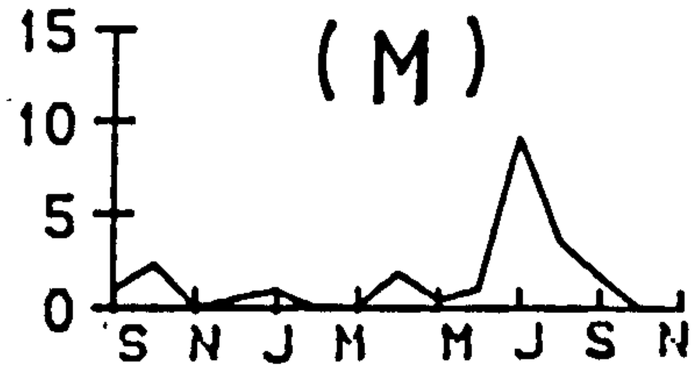
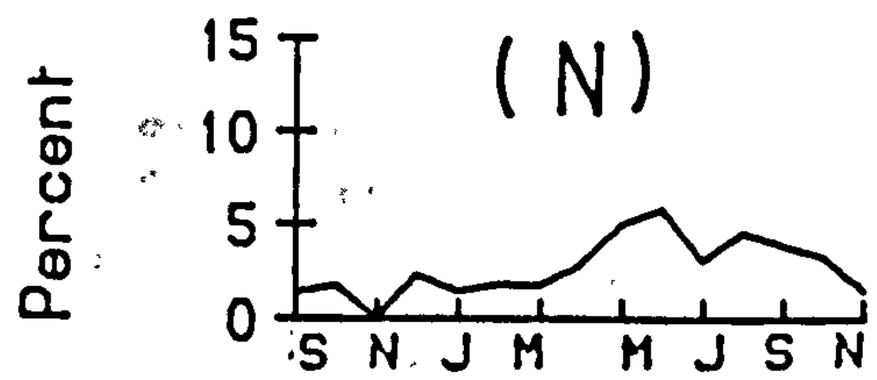
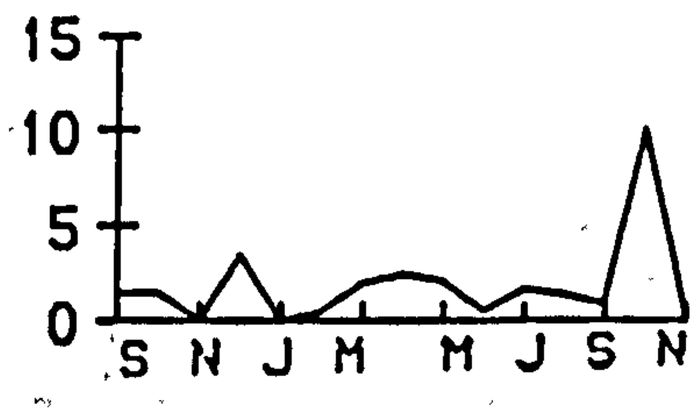


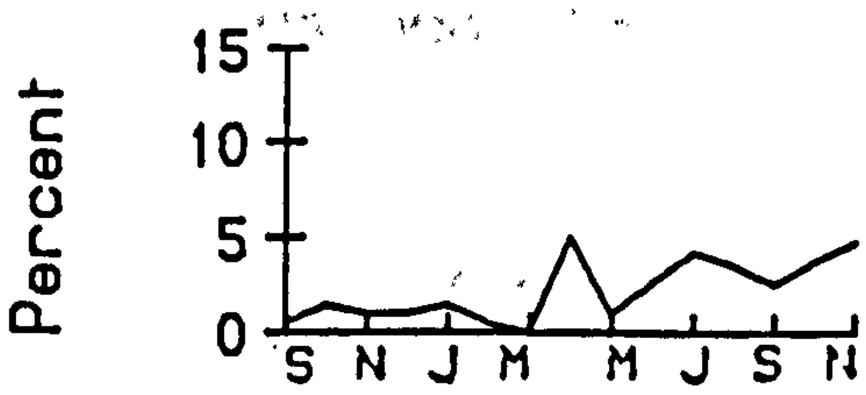
FIG. 5 (Continued)

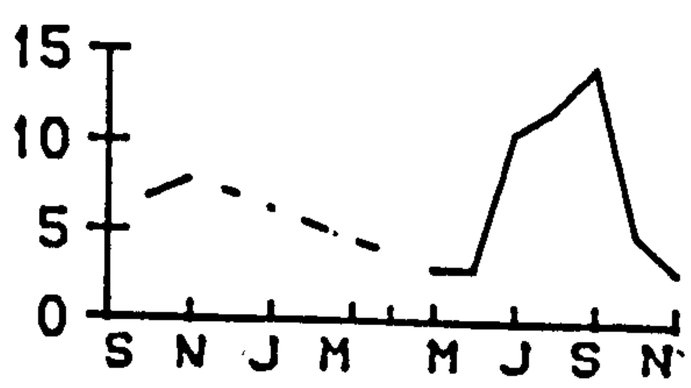
(K) *Ranunculus* spp., (L) *Trifolium repens*.

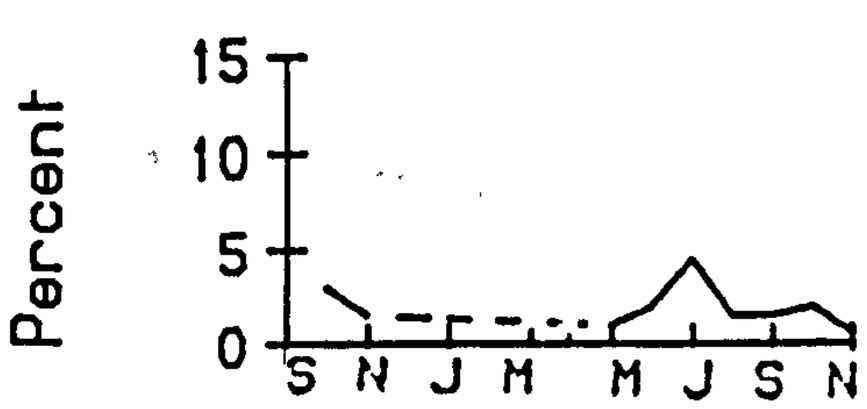












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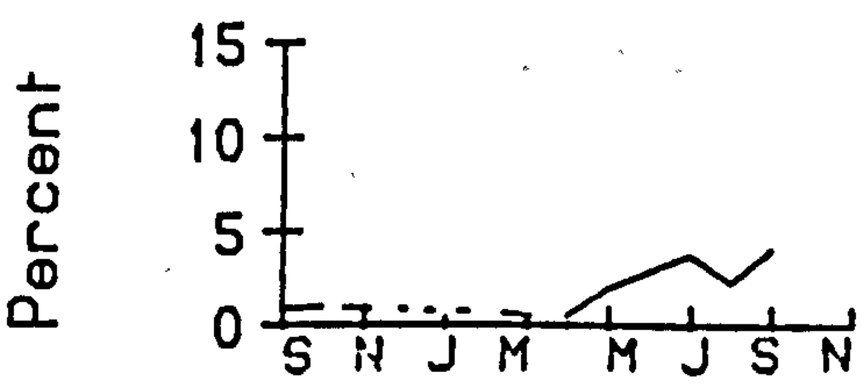
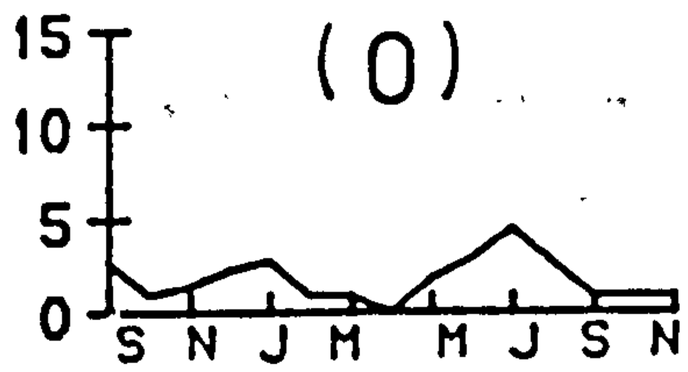
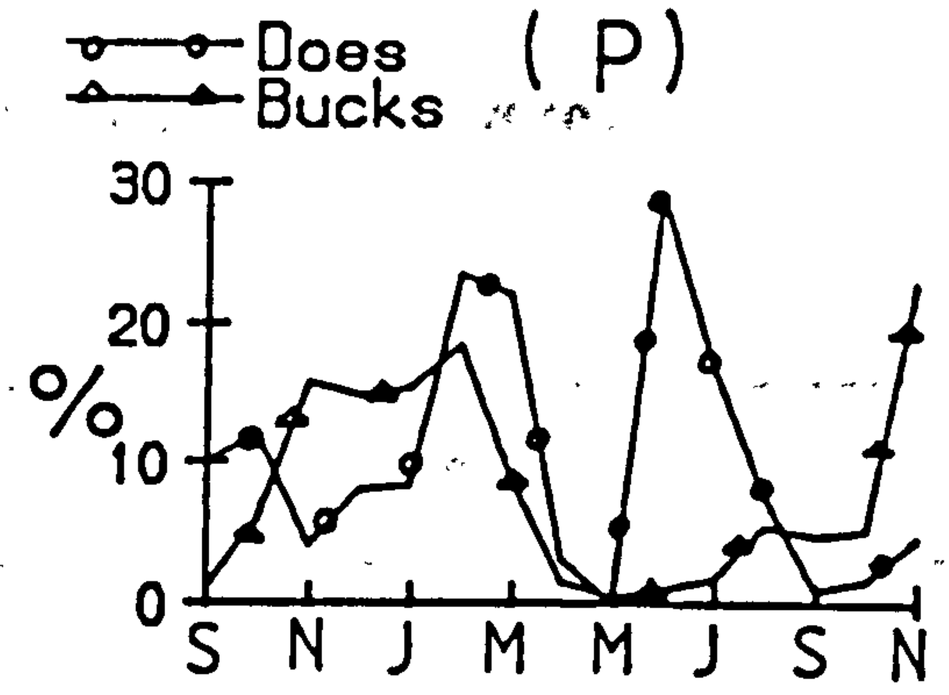


FIG. 5 (Continued)

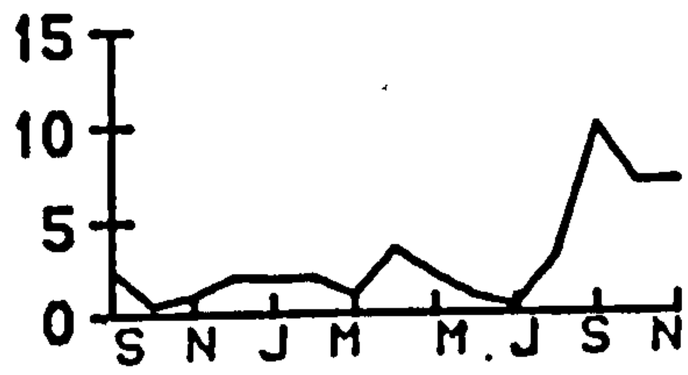
(M) *Taraxacum officinale*, (N) *Prunella vulgaris*.



BUCKS



Taxus baccata



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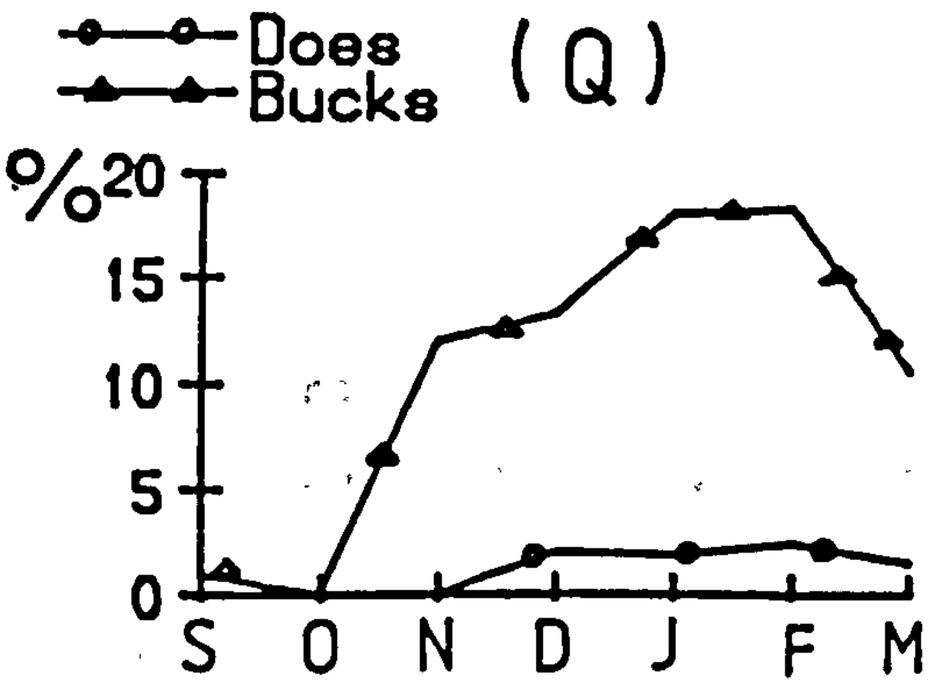
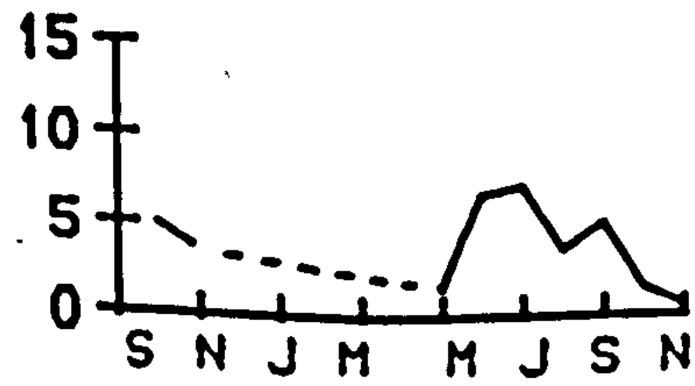
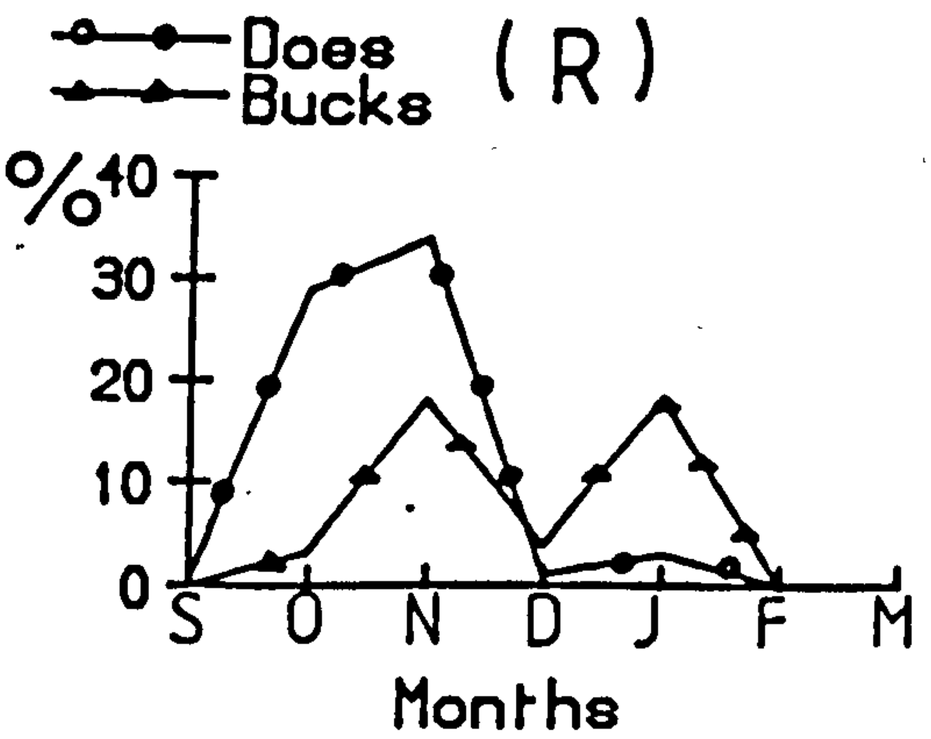


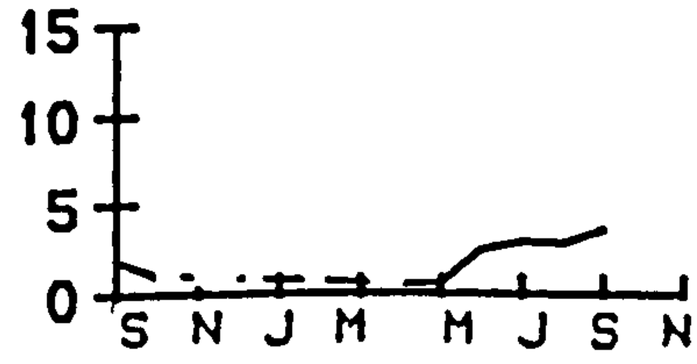
Rubus spp.



CATTLE



MAST



SHEEP

FIG. 5 (Continued)

(O) *Phleum pratense*, (P) *Taxus baccata*, (Q) *Rubus* spp., (R) Mast.

Table 5.4 Similarity indices of diets of herbivores. Paired comparisons.

	Month	B-D	B-C	B-S	D-C	D-S	C-S
1982	September	68		73		74	
	October	57	65	72	47	42	70
	November	62	53		53		
	December	72					
1983	January	76					
	February	77					
	March	63					
1983	April	78		69		79	
	May	70	65	68	75	66	78
	June	45	61	52	46	49	63
	July	62	81	66	55	56	65
	August	75	68	74	59	67	64
	September	68	66	74	65	68	68
	October	53	66		51		
	November	54	51		44		
	Mean	63	64	69	55	63	68

B : Bucks D : Does

C : Cattle S : Sheep

does and cattle which had a yearly average index of similarity of only 55 %. The greatest similarity was between sheep and bucks with a yearly average of 69 %.

Since the cattle and sheep were on the range mainly during the summer months, there was not much scope for seasonal changes in the indices. However, there was a suggestion, when comparing cattle with both bucks and does, that there was substantially less overlap in late autumn than in spring. When comparing only bucks with does, there was no evidence of any consistent seasonal change in the index of similarity.

The index could be compared between years for September, October and November (Table 5.5), and this revealed no significant differences.

Table 5.5 Dietary similarity indices in the same months in two years

Months		B-D	B-C	B-S	D-C	D-S	C-S
September	1982	68		73		74	
	1983	68		74		68	68
October	1982	57	65		47		
	1983	53	66		51		
November	1982	62	53		53		
	1983	54	51		44		

B : Bucks D : Does

C : Cattle S : Sheep

5.4.4 Diet Diversity

The values of the Shannon-Weaver function calculated were 2.77 for bucks, 2.89 for does, 2.63 for cattle and 2.57 for sheep. Thus no great differences are apparent between species although there is a clear suggestion that sheep had the least diverse diets and fallow does the most diverse diets.

5.4.5 Rank Correlation

Kendall's rank correlation co-efficients for the mean diets of herbivores are shown in Table 5.6 below:

Table 5.6 Kendall's rank correlation co-efficients (*) of herbivore diets with the corresponding confidence values.

Relationship	Kendall's τ	P values
Bucks and does	0.66	.001
Bucks and cattle	0.45	.01
Bucks and sheep	0.51	.001
Does and cattle	0.49	.001
Does and sheep	0.54	.001
Cattle and sheep	0.68	.001

*BMDP computer package used to calculate τ (Dixon *et al.* 1983).

The rank order correlation between foods selected by herbivores were all positive and significant. This shows a high degree of concordance for the plants consumed by herbivores. Food plant species ranking in order of abundance (Table 5.7) showed that the first four plant species were the same for bucks, cattle and sheep.

Table 5.7 Ranking of 20 important plant species in the diet of herbivores

Rank	Bucks	Does	Cattle	Sheep
1	Lolium	Lolium	Lolium	Lolium
2	Festuca	(BL Trees)	Moss	Festuca
3	(BL Trees)	Festuca	(BL Trees)	Moss
4	Moss	Taxus	Festuca	(BL Trees)
5	Agrostis	Ranunculus	Holcus	Ranunculus
6	Ranunculus	Moss	Agrostis	Cynosurus
7	Taxus	Mast	Cynosurus	Agrostis
8	Cynosurus	Agrostis	Ranunculus	Taraxacum
9	Deschampsia	Cynosurus	Phleum	Trifolium
10	Mast	Phleum	Taraxacum	Anthoxanthum
11	Taraxacum	Taraxacum	Alopecurus	Dactylis
12	Dactylis	Dactylis	Poa	Phleum
13	Trifolium	Arrhenatherum	Taxus	Holcus
14	Prunella	Prunella	Anthoxanthum	Prunella
15	Holcus	Urtica	Arrhenatherum	Arrhenath.
16	Phleum	Trifolium	Dactylis	Poa
17	Urtica	Holcus	Prunella	Alopecurus
18	Anthoxanthum	Poa	Deschampsia	Taxus
19	Rubus	Cirsium	Trifolium	Deschampsia
20	Cirsium	Deschampsia	Urtica	Urtica

Rank order was different for does. *Lolium* was equally important for all herbivores in that it was the most important plant species in their diet. Next to *Lolium*, *Festuca* was important for bucks and sheep; broad leaved trees for does and moss for cattle. Broad leaved trees ranked 3rd in the diet of bucks and cattle. The same rank was taken by *Festuca* in the diet of does and by the moss in the diet of sheep. Moss ranked fourth in the diet of bucks but sixth in the diet of does, whereas *Taxus* ranked fourth in the diet of does. *Festuca* and broad leaved trees were ranked fourth in the diet of cattle and sheep respectively.

After fourth rank, the situation was more diverse. Except for *Ranunculus* which shared fifth rank between diets of does and sheep, no two species were ordered at the same position in the diets of herbivores. *Agrostis* was ordered at position 5 in the diet of bucks; 6 in the diet of cattle, 7 in the diet of sheep and 8 in the diet of does. *Holcus* was ranked 5 in the diets of cattle but 13, 15 and 17 in the diets of sheep, bucks and does respectively. *Cynosurus* had rankings 6, 7, 8 and 9 in the diets of sheep, cattle, bucks and does respectively. *Ranunculus* ranked sixth and eighth in the diet of bucks and cattle respectively. Mast and Taxus both ranked seven in the diet of does and bucks respectively.

5.5 DISCUSSION

Seasonal data on forage availability were not collected during this study, hence it is not possible to show the exact relationship between forage availability and dietary overlap amongst the herbivores. It is apparent that fallow bucks, does, cattle and sheep while grazing together on the range utilized many of the same species but in differing amounts. In general, the diets were most similar (high overlap) during the period when the forage was available in plenty i.e., in early spring and late summer months. The diets were least similar in June, when the early flush of vegetation had been eaten and in early autumn months, when the herbage mass started

decreasing. This implied that the extensive overlap in the active growth stage did not indicate extensive competition for the abundant and to some extent renewable resource. Least dietary overlap during the autumn months suggests a reduction in competition for the same plant species in the wake of diminishing food resources. The increasing similarity of diets between bucks and does during winter months was, however, associated with lower stocking density. During winter, however, the importance of herbaceous vegetation as the dietary items was considerably reduced and non- herbaceous forage i.e. broad leaved trees, bramble, yew, acorns and even the moss were consumed to higher levels.

Observations on the relationships of dietary overlap amongst herbivores and forage availability have shown conflicting results. Low dietary overlap at a time of low forage availability has been reported by Mackie (1970) for mule deer, elk and cattle grazing on ponderosa pine (*Pinus ponderosa*) - juniper (*Juniperus scopulorum*) and related vegetation types in north-central Montana, U.S.A.; Hansen and Reid (1975) for mule deer, elk and cattle grazing rangelands in southern Colorado, U.S.A.; Hanson and Clark (1977) for elk, mule deer, wild horses and cattle grazing 10 different rangelands in north-western Colorado, U.S.A.; Olsen and Hansen (1977) for elk, wild horses, pronghorn antelope, cattle and sheep in the Red Desert, Wyoming, and by Hobbs *et al.* (1983) for elk, mule deer and mountain sheep using montane winter range in Rocky Mountain National Park, Colorado. Existence of high overlap at a time of low forage availability was reported by Anthony and Smith (1977) for mule deer and white-tailed deer in south-eastern Arizona; by Singer (1979) for moose (*Alces alces*), elk and white-tailed deer in Glacier National Park, Montana; Schwartz and Ellis (1981) for bison, pronghorn, domestic cattle and sheep grazing the short-grass prairie in north-eastern Colorado, and by Leslie *et al.* (1984), for Roosevelt elk and Columbian black-tailed deer using old- growth forests in western Washington.

The present study, however, supports the contention that the overlap was low at a time of low forage availability, when all the herbivores were on the range.

Ranking of plant species showed the importance of *Lolium* for all the herbivores. The other species, however, varied in their importance to the herbivores. The high degree of concordance for the plants selected by the herbivores suggests a possibility of competition. The intensity of competition however, is to be considered in the context of forage availability, stocking density, and their effect on the range. In the absence of information on forage availability and range condition trends it is not possible to document the intensity or the effects of competition on the range or on the animals.

Higher diversity of plants in the diets of does suggests more equitable consumption of different plant species as compared with the other herbivores. The least diversity in the diets of sheep showed a less equitable use of forage plant species. Diets of sheep contained 21.6 % *Lolium*, 15.8 % *Festuca* and 14.6 % moss, all in higher proportions than those taken by the other herbivores (Table 5.3). In terms of diversity of plants in the diet, the herbivores could be ranked from the diverse selectors to least diverse selectors as : does, bucks, cattle and sheep respectively.

At the Deer Park *Lolium* was most frequently eaten grass species by all the herbivores. Milner and Gwynne (1974) also showed that Soay sheep at Island of Hirta consumed *Lolium* more than *Agrostis* in May and June, though the availability of *Agrostis* was more than that of *Lolium*. *Festuca* was the second most frequently occurring species in the diets of bucks and sheep and the second most frequently occurring grass species in the diets of does and cattle. Preferential use of *Festuca* by Soay sheep has been reported by Milner and Gwynne (1974), whereas higher proportions of *Festuca* in comparison with *Agrostis tenuis* were found in the diet of sheep (Martin 1964), sheep and red

deer (Colquhoun 1971), and sheep and feral goats (Bullock 1985).

Higher use of *Holcus* towards the end of the year by cattle, bucks and does as in the present study has also been shown by Milner and Gwynne (1974) for Soay sheep which consumed higher proportions of *Holcus* in early November followed by a decrease up to February, an increase in spring which peaked in late summer. Lower consumption of *Agrostis* and *Holcus* and higher consumption of *Festuca*, as at Hopetoun House Deer Park has also been documented by Milner and Gwynne (1974) for Soay sheep. Little use of *Poa* spp. in the present study is, however, opposed to the findings of Milner and Gwynne (1974) who reported *Poa* to be consumed in higher proportions.

Higher use of *Cynosurus* in late summer is consonant with its growth pattern, i.e. most of its yield is produced late in the year (Moore 1966; Spedding and Diekmahns 1972). Low leaf-stem ratio and the high proportion of unpalatable stem later in the year (Spedding and Diekmahns 1972) makes the grass less available to the herbivores.

The use of forbs, in the present study increased in the spring months when they started growing profusely. Their use peaked in June when the diets of bucks contained 43 % forbs. The second flush of growth in the autumn was utilized more by the does which took 41 % forbs in their diet. The bucks were rutting during this period. The higher use of forbs during spring and summer months has also been well documented in literature (Van dyne and Heady 1965 (b); Cook *et al.* 1967; Bedell 1968; Dudzinski and Arnold 1973; Hobbs *et al.* 1983). Martin (1964) has reported the increased use of infrequent *Trifolium* spp. and *Lotus* spp. from the Scottish hill pastures by blackface sheep from April to September and argued that these were being selected in preference to other species. Use of forbs has not been reported in other studies made on Scottish hill pastures.

The spring growth of broad leaved trees was used quickly and a distinct browse line about 1.5 m high was obvious soon after the first

flush of growth. Thereafter, during the summer browse was generally out of reach. Falling leaves during autumn were also picked up quickly thus producing another peak of broad leaved trees in the diets during the autumn months.

High consumption of moss, as found in the present study has also been shown by other research workers. Sheep in Perthshire took mosses up to 32 % and 33 % of their diet in April and August, whereas the diets of red deer contained mosses up to 27 % of the total in February (Colquhoun 1971). Bullock (1985) showed that the feral goats and upland sheep consumed more mosses in early spring and autumn months than other times of the year. .The consumption of mosses was, however, not reported by Martin (1964), and Milner and Gwynne (1974).

There is some debate as to whether mosses are actively selected or whether they are ingested accidentally with other food items. At Hopetoun they were taken most during late autumn, winter and early spring. This could equally have been because they selected mosses when other forage was less available or because the forage matt was low, they were less able to avoid mosses whilst cropping closely for other forage. It is not possible from this study to shed further light on the problem.

The diet of fallow deer at Hopetoun can be compared with their diet in the New Forest, southern Engalnd, the only other area for which details are available (Jackson 1974).

The diets of bucks and does at Hopetoun showed a varying pattern. Significant differences were found in the use of plant species in some months whereas for most months, there was no significant difference in the composition of their diet. Jackson (1974) found the diets of bucks and small deer (including does, yearlings and fawns) to be very similar.

Bucks at Hopetoun consumed grasses from 48 % to 68 % in the

period March to October, the highest amount taken in October. The diets of does contained 34 - 67 % grasses during the same period. The peak use was in September. Comparatively less grasses were used during winter. Fallow at New Forest consumed about 55 - 75 % grasses from March - September. Forbs in the present study were important throughout summer both for bucks and does, with a higher use by bucks in late spring (43 % in June;) and by does late in the year (41 % in November 1983). The diets of fallow in New Forest contained 5 - 30 % forbs from April to August, with the peak in August. Broad leaved trees were not important for the bucks during summer, whereas the diets of does contained 16 % foliage of trees in May and July, the pre-fawning and post-fawning period when the does tended to be in secluded more wooded parts of the range. Bucks consumed high proportions of broad leaved trees in the autumn months - October, November 1982 and September, October 1983, whereas does consumed high proportions of the foliage from broad leaved trees only in September, October 1982. Broad leaved trees for fallow at New Forest were important from April to June. Mast in the present study was important only during autumn 1982, which was a good mast year. At New Forest also mast was important only from October to December, in good mast years. Bramble, the only bush available to fallow deer at the Deer Park was important only for bucks and only during November to March. At the New Forest the fallow utilized bramble and rose bushes heavily from August to February with a peak in January. Conifers were the main food during winter for the fallow at the New Forest, but much of it came from the brash, left after forestry operations. *Taxus*, the only conifer available at the Deer Park was important for bucks from November to February, and for does during the fawning season of June and July, 1984. Consumption of *Taxus* by captive fallow deer has also been reported by Chapman and Chapman (1975). *Taxus* is reported to be fatal if taken in excessive amounts (Chapman and Chapman 1975). No such effect was reported either by Chapman and Chapman (1973), or noticed in this study, though use of *Taxus* was (32 %) in the diet of does in June.

As opposed to the findings in the present study, mosses were not reported to be taken by fallow at the New Forest.

Overlap in the diets, concordance of food plant species, and little difference in the diversity of food plants in the diets of herbivores suggests a possible competition amongst them. In the absence of data on forage availability, and range condition trend, competition can be thought to occur if the performance of animals on the range is being affected, which would be possible only if the nutritional levels of their diets would be less than that required for their maintenance, growth, reproduction, lactation or wool production. This aspect of range use will be discussed in the next chapter.

5.6 SUMMARY

1. Diet composition of herbivores was determined by microhistological analysis of faecal pellets/dung.
2. Stomach contents and rectal faecal contents of culled bucks and does were compared microhistologically but no differences were found in the results obtained by using both the methods.
3. Dietary similarity indices were higher at a time of higher forage availability, and lower at a time of lower forage availability.
4. Sheep diets were the least diverse in their composition, and the does diets the most diverse but there was no significant difference in the diversity of diets consumed by herbivores.
5. *Lolium* ranked highest in the diet of all herbivores. The first four highest ranking species were the same in the diets of bucks, cattle and sheep, though at different ranks,after which the ranks differed widely. The ranking of doe diets was different from those of the other herbivores.
6. Cattle and sheep consumed more grasses and less forbs as compared to does and bucks.
7. All the herbivores consumed more broadleaved tree foliage during spring and autumn.

8. Does consumed higher amounts of *Taxus* in the fawning season.
9. Oak acorns were important for deer only during autumn, in a good mast year.
10 Sheep and cattle utilized more moss than did the deer. Moss was however, more in the diets of deer during winter.

6 NUTRITIONAL QUALITY

6. NUTRITIONAL QUALITY

6.1 INTRODUCTION

The management of rangelands requires a thorough understanding of the benefits the animals derive from each forage species. Thus in addition to a description of the species composition of the animals' diets an assessment of the nutritional quality of each species in the diet is needed. The nutritional quality must also be assessed in relation to the animals' nutritional requirements. Both quality of forage and the animals' requirements can be expected to change seasonally.

In the previous chapters it was shown that the fallow deer, cattle and sheep on the parkland at Hopetoun differed significantly in their selection of foraging areas and in the species of forage they consumed, thus supporting the argument that the multiple species grazing makes better use of the rangeland. However, for this argument to be acceptable it is necessary also to demonstrate that each of the three species obtained an adequate overall level of nutrition from the range.

This chapter, therefore, examines the quality of forage taken by the herbivores and assesses the overall quality of their diet in relation to their requirements.

6.2 METHODS

6.2.1 Forage Quality

Ideally, analysis should be made of the material actually consumed by the animal. The most direct method of doing this would be by the use of fistulae (Van Dyne and Torell 1964, Van Dyne and Heady 1965 (a, b). However, there are many problems associated with this. Fistula samples are liable to contamination with regurgitated rumen

contents and to chemical changes during mastication and salivation. Also separation of the sample into its constituent species is difficult and liable to error. In the case of the fallow deer in this study the problems are especially severe. The deer are semi wild and the use of the fistula method requires that the animals be captured at frequent intervals. Whatever capture method was employed there would be serious effects on the animals through stress. Also the presence of the general public in the parkland made fistulae undesirable.

The only alternative method available involves the collection of samples directly from the range and this method was employed in the present study.

Known food plants were plucked simulating the bite of herbivores. Dry leaves of broad leaved tree species were collected in December, fresh leaves in May and falling leaves in September. The current year's growth of *Taxus* was collected from the lower branches or epicormic shoots from the stems, which were seen to be eaten by the deer. Current year's growth of bramble was also collected and during February and March when there were no leaves on the shrub, twigs up to 10 cm from the tip were collected. The samples, separated according to species, were oven dried at a temperature of 60^{oC} for 36 hours, then ground in an ultra centrifugal mill using 1.00 mm sieve. Chemical analyses were carried out for all plant species that made up 5 % or more in the faecal pellet analyses for any particular month. Nitrogen was determined using the autoanalyser methods (Crooke and Simpson 1971); phosphorus (P) by the rapid digestion method (Bolin and Stramberg 1944, Murphy and Riley 1962); calcium (Ca) and magnesium (Mg) using atomic absorption spectrophotometry, and sodium (Na) and potassium (K) using flame emission spectrophotometry (Boettner and Grunder 1968). Lathanum oxide was added to Ca and Mg samples to reduce interference caused by phosphorus. Nitrogen was converted to crude protein by multiplying with 6.25 (McDonald *et al.* 1966). *In vitro* dry matter digestibility of all the forage species was determined at Hill Farming Research Organization(HFRO) using the two

stage (rumen liquour-acid pepsin) method developed by Tilley and Terry (1963), as modified by Alexander and McGowan (1966). Rumen liquour used in fermenting the plant species was taken from fistulated sheep fed on a high quality *Lolium* (ryegrass) hay. The feed was also supplemented with high quality pelleted rations (18 % crude protein). All determinations were done in duplicate and the results averaged. Each year feeding trials are conducted at HFRO to calculate estimates of *in vivo* digestibility. On the basis of these, the figures obtained in this study for *in vitro* digestibility were converted to *in vivo* digestibility using a computer programme developed by John Rogers of HFRO.

6.2.2 Total Diet Quality

Overall diet quality was calculated by multiplying the nutritional contents of each food species with the proportions of that species in the diet, following the formula presented by Westoby (1974):

$$N_i = \sum_{j}^{n} a_{ij}\ x_j$$

whereas N_i = diet content of a specific nutrient content
X_j = proportion of jth forage species in the diet
a_{ij} = ith nutritional content of the jth plant species.

The percentage of crude protein, phosphorus, calcium, potassium, sodium, magnesium and estimated *in vivo* dry matter digestibility (IVDMD) in monthly diets was calculated using nutritional levels of plants in that particular month. In the few cases where a plant species occurred in the diet, but was not collected for nutritional content analysis, the values for a closely related species in the same forage class were used. Broad leaved trees could not be identified in

the diet as individual forage plant species. The foliage of the following tree species was, therefore, analysed: *Acer pseudoplatanus*, *Fagus sylvatica*, *Fraxinus excelsior*, *Quercus ilex*, *Q. robur*, *Sambucus nigra*, *Tilia europea* and from these an average value taken for use in diet quality analysis.

6.3 RESULTS

6.3.1 Nutritional Requirements

Nutritional requirements have been defined as the minimum amount of a particular nutrient needed to promote a given body function to the optimum (Halls 1970). Requirements are, therefore, related to age, species, level and type of production, level of parasitism and environmental stresses such as changes in temperature. The determination of requirements involves feeding trials at different nutritional levels and measuring the response in weight, growth and reproductive performance. Standards are generally available for domestic livestock (NRC 1975, 1976, 1978; ARC 1980). However, few data are available for wild ungulates and nothing is available for fallow deer. Information is available for only one deer species, the white- tailed deer in the U.S.A. Clearly the extensive feeding trials needed to establish requirements could not be undertaken in this study. Therefore, the data for white-tailed deer were used for the fallow deer.

The known requirements of sheep, cattle and white-tailed deer are given in Table 6.1. The following criteria have been used to decide upon the requirements:

Deer: Fallow deer and white-tailed deer are approximately similar in size (body weight: fallow deer, 40 kg; white-tailed deer 39 kg; Prins and Geelen 1971), thus the requirements for CP set by French *et. al.* (1955) for maximum gain and reproduction (13 %), and for maintenance during winter (7 %), and for Ca and P (0.60 % and 0.56 % respectively,

Table 6.1 Threshold values (% dry matter)for nutritional requirements of herbivores.

Nutrient	Requirements for Deer		Cattle		Sheep
	Maintenance winter	+growth	Lactating (Oct/Nov)	Growing	
Crude protein	7.00	13.00	13.0	10.70	10.70
Calcium	0.64	0.30		0.43	0.30
Phosphorus	0.56	0.25		0.31	0.28
Ca:P ratio	1.1 to 5:1				
Potassium		0.20-0.30		0.80	0.50
Sodium		0.10-0.20		0.18	0.20
Magnesium		0.06		0.20	0.06
Dry matter digestibility		50		50	50

and 0.30 % and 0.25 % during winter) set by Magruder *et. al.* (1957) for best antler growth were taken as standard. Though it is implied that Ca requirement of lactating does during the period they suckle their fawns would be more. The requirements of growing heifers and lactating cows has been reported not to be very different (NRC 1976, 1978), therefore, the requirement of growing deer was taken as standard. Requirements for potassium (0.2-0.3), sodium (0.1-0.2 %), and magnesium(0.06 %), as reported by Maynard and Loosli (1969) were taken as standard.

Cattle: The cattle on the range are kept as breeding stock. The milk is utilized only by the calves. The requirement of CP (13 %) for lactating cattle with milk yield >8 kg (NRC 1978) was taken as standard for the months October and November, when the calves were born. For other months cattle were on the range, requirement for growing heifers 200-400 kg body weight, with 1 kg daily weight gain (10.7 %) was set as standard (ARC 1980). For the mineral requirements, however, requirement for the lactating cows (NRC 1978) were taken as standard.

Sheep: Sheep are also maintained as the breeding stock. 6-month old lambs are put on the range only for about 3-4 weeks by the end of summer. The CP requirements for an ewe of body weight 30-40 kg to maintain itself with a daily weight gain of 20 g was taken as standard (10.7 %) (ARC 1980). Ca, P, and K requirements set by NRC (1975) (no figures reported by ARC 1980), and Na, Mg requirement, set by ARC (1980) were taken as standard.

6.3.2 Forage Quality

Results of the chemical analysis on principal forage species are shown in Tables 6.2.1 to 6.2.8. The asterick marks in the tables show the values of nutritional contents below the recommended/required levels (threshold values, Table 6.1) for maintenance and growth, for deer and for cattle and sheep separately.

In general, all the forage species had very low nutrient concentrations during the winter months i.e., up to March, after which a slight increase was obvious in April but concentrations of all the nutrients increased very rapidly in May. Concentrations decreased after June but increased again in September to November. The same trend has been reported for *Agrostis-Festuca* swards in upland grasslands (Brasher and Perkins 1978). *In vivo* dry matter digestibility also showed the same trend. The results have been discussed by plant-groups i.e., grasses, forbs, browse and moss.

Grasses

Crude protein: Crude protein content of grasses during winter months was higher than the minimum required level (7 %) for the maintenance of deer. *Holcus lanatus* had the highest CP content during the months December to March. CP content in *Dactylis glomerata* and *Deschampsia cespitosa* was also high in February-March.

In other times of the year, total grasses, on average were deficient in CP for all herbivores in July, August, and only for deer in June, September and October. April was the only month when none of the grasses was deficient in CP content (> 13%). CP content in *Agrostis tenuis* was below the required levels for deer in July, September and November and below the levels required by all herbivores in September. *Cynosorus cristatus* was deficient in CP for all herbivores from May to October. *Dactylis* and *Lolium perenne* were deficient for deer in August and for all herbivores in July. CP concentration of *Deschampsia* was low for deer from July to September and in November and for all herbivores in October. *Festuca rubra* showed deficiency for deer in May, September and November and for all herbivores in July, August. *Holcus* was deficient for all herbivores in the period June to October. *Phleum pratense* was deficient for all herbivores from July to September and for deer in October. *Poa* had lower CP levels than recommended for all herbivores in June, July and for deer from August to October.

Calcium: Grasses on average contained adequate levels of Ca (>0.30%) during December-January and marginal levels in February-March. *Deschampsia* had the least Ca content, whereas *Dactylis*, *Festuca* and *Holcus* had very high Ca concentrations. *Lolium* was marginally deficient in January and March. *Agrostis* and *Phleum* had the required levels only in January and *Cynosurus* in December and January.

For other times of the year, Ca content in grasses, on average, was below the required levels for deer (< 0.60%) in April, July, August and October, and deficient for all herbivores (< 0.43%) in May, June, September and November. Except for July and August *Agrostis* was deficient in Ca content, for deer in April, June and September and for all the herbivores in May, October and November. *Cynosurus* contained lower levels of Ca for all herbivores in September, October, and for deer only in all other months. *Dactylis* was deficient for deer in April, August and October and for all herbivores in other months. Ca concentrations in *Deschampsia* were about adequate in August, deficient for deer in April, June and July, and deficient for all herbivores in other months.

Levels of Ca in *Festuca* were adequate in April, September and October, lower for deer in July, August and November, and lower for all herbivores in May, June. *Holcus* and *Lolium* had adequate levels of Ca for deer only in July. The former had adequate Ca levels for sheep and cattle in April and August only. *Phleum* contained required Ca levels for deer in July and November, and for cattle and sheep in August only. *Poa* was deficient in Ca for deer in August and for all herbivores in May and June.

Phosphorus: Grasses on average were greatly deficient (< 0.25%) in P during winter. *Holcus* from December-March, *Lolium* from January to March, and *Dactylis* and *Deschampsia* in March contained adequate levels of P. During all other months of the year also grasses on average were deficient in P for deer (< 0.56%), and for cattle and

sheep as well in July and August (< 0.30%). Grasses containing P about the required level were: *Dactylis* in May and September; *Holcus* in April, May; *Lolium* in September and *Poa* in November. P contents adequate for cattle and sheep (> 0.30%) but inadequate for deer was determined in *Agrostis* in May, October, November; *Cynosurus* in April and November; *Dactylis* in April, June, October, November; *Deschampsia* in April, October, November; *Festuca* in June and August to October; *Holcus* from July to November; *Lolium* except for May and September; *Phleum* in April, October, November, and *Poa* in May. For all other occasions, grasses were deficient in P for all herbivores.

Ca:P ratio: An adequate Ca:P ratio is considered to be within the range 1:1 to 2:1 (McDonald *et al.* 1966). Higher levels of Ca may affect the utilization of P. Owens and Gill (1979) have, however, reported that a ratio 5:1 may not even be harmful, for the feedlot cattle. Ratio, less than 1:1 have, however, been considered deleterious. Wise *et al.* (1963) have however, suggested that a range of 1:1 to 7:1 may be tolerable. An optimum ratio has been reported to be 1.3:1.0. On average, Ca:P ratio in grasses was within the range, except for May and November when it was marginally less than 1:1. *Phleum* had a ratio 5.58:1 in July. Ratios lower than 1:1 were found for *Dactylis* during May to July, September and November; for *Holcus* in April, May, and November; for *Lolium* in April, June and November; for *Poa* in May, and for *Agrostis*, *Cynosurus* and *Deschampsia* in November.

Potassium: K was not deficient in any of the grass species at any time of the year.

Sodium: Grasses were generally deficient in sodium. For total grasses averaged, Na content was adequate (> 0.18%) in July, and marginally lower in June and August. Adequate levels of Na were found in *Cynosurus* in May-July; in *Dactylis* in July and November; in *Holcus* in June, July; in *Lolium* from May-August, and in *Poa* in August. *Lolium* on an average contained adequate levels of sodium.

Magnesium: Mg was not deficient for deer during winter months. In other months Mg was adequate for deer and sheep (> 0.06%) but not for cattle (< 0.20%). Mg was not deficient in *Agrostis* in June, July; *Dactylis* in June, July and September; *Lolium* in June; *Phleum* in July and *Poa* in July, September and October.

In vivo dry matter digestibility (estimated): The digestibility of a forage is the portion assumed to be absorbed by the animal during digestion. Amman *et al.* 1973 has reported that 50 % digestibility of a forage species could be considered as optimum. IVDMD of grasses was generally low during winter months. IVDMD higher than 50 % was determined for *Dactylis* in February, March; for *Holcus* from January to March and for *Lolium* in March. IVDMD of total grasses, averaged in all months of the year was more than 50 % except in July, when all grasses except *Festuca* and *Lolium* had lower digestibility co-efficients. Lower IVDMD was also determined for *Agrostis* and *Poa* in September, for *Cynosurus* in September, October, for *Deschamsia* from August to October, and for *Phleum* in October.

For the months April-November, *Lolium* on the average was the most digestible (hence most nutritious) grass species followed by *Dactylis*, *Holcus*, and *Festuca*.

Forbs

Nutritional contents of forbs were determined only for the months from April-November, when the forbs were present on the range. Nutritional contents were generally higher in early spring, decreased from late spring, and again increased during the autumn months. Forbs showed distinctly higher values of nutritional contents than grasses.

Concentrations of crude protein, calcium, potassium and magnesium were higher than the required levels, over all the months. *Prunella*, however, was deficient in crude protein only for deer in June.

Phosphorus levels were less than required for deer in *Prunella* for November, in *Ranunculus* for all months except September; in *Taraxacum* for all months, the species was analysed. *Trifolium* was deficient in P for deer in April and from August to November, and for all herbivores from May to July. P in *Urtica* was deficient for deer in July and for all herbivores in September. For total forbs averaged, P levels were less than that required for deer but only marginally so in April, May and August.

Ca:P ratio in forbs was generally within the range 1:1 to 5:1 but was wider in *Trifolium* from May-July and in *Urtica* in July and from September to November.

Sodium for all forbs averaged was deficient only in May. Na content was below the required levels (< 0.18%) in *Ranunculus* in May; in *Taraxacum* in May, September, October, in *Trifolium* in April, May and in *Urtica* from April to September.

IVDMD was always more than 50 %, *Trifolium* on the average was the most digestible (74 %:), followed by *Taraxacum* and *Ranunculus*.

Browse

Broad leaved trees were deficient in CP during winter, in phosphorus for deer during spring-summer months and for all herbivores during autumn. Potassium content of broad leaved species was below the required levels during winter. Sodium was deficient during all times of the year. IVDMD was also lower at all times of the year, and was even less than 20 % for the dried foliage collected in December.

Taxus baccata had adequate levels of CP (> 7.0%) during winter months. CP levels in July and November were below that required for deer (< 13.0%) and during April to June and August to October below the requirement of all the herbivores. *Taxus* was not deficient in K and Ca but P was below the required levels for deer in March, July to

September and November and below those for all herbivores from April to June and October. Ca:P ratio was wider than 5:1 in April and June. Sodium was deficient only in May, whereas Mg was deficient in all months. IVDMD was lower than 50 % only in March, September and October.

Bramble (*Rubus* spp.) was consumed by the deer only during winter months, December to March. Except in March when CP content was 9.23 %, CP levels were about 13 % (required for maximum growth). Ca, K and Mg levels were above the required levels. P was lower only in February, and sodium in all months i.e., December to March. IVDMD was, however, lower than 50 % but more than 40 %.

Oak acorns were low in CP, Ca, P, Ca:P ratio, Na and Mg but adequate in K levels. IVDMD was 65 %, which may be the reason for their higher intake when these were available in autumn.

Moss

CP contents of the moss were adequate for deer during winter months (> 7.0%). CP content was below the required level for deer (< 13.0%) in September and November and for all herbivores in other months. Ca was adequate for winter months but below the level for deer in April, May and June. P was deficient for deer in February, March, September and for all herbivores in other months. Ca:P ratio, however, was within the range 1:1 to 5:1. K was adequate and Na deficient for all months. Mg content was below the required levels for cattle during April to June and November, and for sheep and deer in July. Moss was least digestible during winter months, in December and January IVDMD was only 14 and 13 % respectively. IVDMD ranged between 30 % and 40 % in other months, about 31 % in June, October and November, and about 38 % in July, August and 40 % in September.

Table 6.2.1 Crude protein contents, percent dry matter, of principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis							+	+	*			+
	9.3	9.1	8.9	11.3	13.6	16.3	13.8	11.4	12.6	9.2	14.7	12.7
Cynosurus cristatus						*	*	*	*	*	*	
	8.0	7.5	6.8£	10.1	14.6	9.2	9.4	5.6	6.3	7.2	10.0	17.4
Dactylis glomerata							*	*			+	
	8.3	8.8	12.5	16.2	16.4	17.6	16.7	8.9	10.6	17.7	12.6	19.2
Deschampsia cespitosa						+	+	+	+	*		+
	7.5	7.5	14.3	15.4	17.3	13.9	12.6	10.9	10.9	10.5	9.9	11.5
Festuca rubra				+	+			*	*	+		+
	8.8	8.6	9.3	10.0	12.8	12.1	14.0	10.2	10.0	12.3	13.7	12.5
Holcus lanatus							*	*	*	*	*	
	12.6	14.3	14.9	13.7	16.6	15.9	9.8	8.9	8.6	6.4	9.9	21.6
Lolium perenne								*	+			
	9.3	11.9	10.4	9.9	17.2	13.9	15.6	9.6	10.3	15.4	13.2	20.0
Phleum pratense								*	*	*	+	+
	7.9	8.9	10.1	7.7	13.3	---	---	7.6	7.4	7.6	10.8	12.8
Poa spp.							*	*	+	+	+	
	---	---	---	---	---	14.8	10.0	9.1	12.2	10.3	11.9	23.1
Mean grasses							+	*	*	+	+	
	9.0	9.6	10.3	11.8	15.2	13.5	12.6	9.1	9.8	10.7	11.9	16.8

(continued)

* Less than 10.7 % , requirement for cattle and sheep
\+ Less than 13,0 % , requirement for cattle during Oct.,Nov.
\+ Less than 13.0 % , requirement for deer except winter
£ Less than 7.0 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.1 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	10.8	13.1	13.5	20.1	---	14.4
Ranunculus spp.	---	---	---	---	19.9	14.1	15.0	16.5	14.1	18.8	15.3	18.3
Taraxacum officinale	---	---	---	---	17.3	14.6	---	---	---	18.8	12.7	24.2
Trifolium repens	---	---	---	---	21.2	18.7	13.4	21.4	20.0	24.4	25.4	22.5
Urtica dioica	---	---	---	---	22.3	19.2	18.8	17.3	21.0	21.9	25.3	26.5
Mean forbs	---	---	---	---	20.2	16.7	14.5	17.1	17.2	20.8	19.7	21.2
Rubus spp.	13.0	12.9	13.1	9.2	---	---	14.2	11.9	11.9	12.3	---	---
Taxus baccata	12.3	12.2	9.0	10.6	10.0	8.5	6.6	10.5	9.8	9.4	6.4	10.8
Moss	8.6	8.9	9.7	8.9	10.3	8.1	10.2	8.5	10.1	11.3	9.3	11.2
Broad leaved trees	5.7£	5.7£	5.7£	5.7£	5.7£	18.5	18.5	18.5	18.5	16.9	16.9	16.9
Mast	7.4£											

* Less than 10.7 % , requirement for cattle and sheep
\+ Less than 13,0 % , requirement for cattle during Oct.,Nov.
\+ Less than 13.0 % , requirement for deer except winter
£ Less than 7.0 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.2 Calcium contents, percent dry matter, of principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis	0.24£	0.35	0.21£	0.25£	0.45 +	0.36 *	0.53 +	0.64	0.60	0.43 +	0.38 *	0.23 *
Cynosurus cristatus	0.31	0.28	0.19£	0.21£	0.45 +	0.44 +	0.46 +	0.52 +	0.46 +	0.35 *	0.34 *	0.27 £
Dactylis glomerata	0.47	0.30	0.26£	0.32	0.40 +	0.31 *	0.32 *	0.17 £	0.45 +	0.32 *	0.40 +	0.26 £
Deschampsia cespitosa	0.18£	0.17£	0.19£	0.21£	0.40 +	0.24 £	0.41 *	0.40 +	0.53 +	0.27 £	0.19 £	0.24 £
Festuca rubra	0.39	0.34	0.35	0.25£	0.57 +	0.33 *	0.30 *	0.40 *	0.49 +	0.68	0.73	0.46 +
Holcus lanatus	0.41	0.36	0.33	0.28£	0.41 *	0.36 *	0.37 *	0.66	0.40 *	0.26 £	0.29 £	0.32 *
Lolium perenne	0.37	0.25£	0.29£	0.25£	0.37 *	0.43 +	0.39 *	0.66	0.38 *	0.34 *	0.33 *	0.27 £
Phleum pratense	0.27£	0.34	0.27£	0.21£	0.35 *	---	---	0.67	0.43 +	0.29 £	0.51 +	0.64
Poa spp.	---	---	---	---	---	0.34 *	0.36 *	0.74	0.42 *	0.58 +	0.83	0.66
Mean grasses	0.33	0.30	0.25£	0.25£	0.43 +	0.34 *	0.39 *	0.54 +	0.45 +	0.39 *	0.44 +	0.37 *

(continued)

* Less than 0.43 % , requirement for cattle and sheep
\+ Less than 0.60 % , requirement for deer except winter
£ Less than 0.30 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.2 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	1.00	1.23	0.94	0.94	---	0.64
Ranunculus spp.	---	---	---	---	1.52	0.76	1.10	1.70	1.39	1.11	1.12	0.71
Taraxacum officinale	---	---	---	---	1.01	1.01	---	---	---	1.26	0.89	1.35
Trifolium repens	---	---	---	---	1.50	1.23	1.02	1.39	1.31	1.48	0.97	0.69
Urtica dioica	---	---	---	---	2.26	1.90	2.56	2.92	2.07	3.29	4.23	3.96
Mean forbs	---	---	---	---	1.57	1.23	1.42	1.81	1.43	1.62	1.80	1.47
Rubus spp.	0.97	0.93	0.76	0.94	---	---	0.67	0.67	0.73	0.77	---	---
Taxus baccata	0.71	0.63	0.75	0.63	0.90	0.66	0.66	0.51	0.49	0.63	0.60	0.70
Moss	0.39	0.36	0.40	0.32	0.52+	0.44+	0.42+	0.77	0.60	0.44+	0.70	0.73
Broad leaved trees	1.22	1.22	1.22	1.22	1.22	0.75	0.75	0.75	0.75	0.73	0.73	0.73
Mast	0.12£											

* Less than 0.43 % , requirement for cattle and sheep
\+ Less than 0.60 % , requirement for deer except winter
£ Less than 0.30 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.3 Phosphorus content, percent dry matter, of principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis	0.21£	0.15£	0.14£	0.16£	0.24	0.42	0.27	0.27	0.22	0.24	0.37	0.31
Cynosurus cristatus	0.14£	0.13£	0.12£	0.18£	0.29	0.23	0.24	0.13	0.13	0.15	0.23	0.30
Dactylis glomerata	0.15£	0.19£	0.21£	0.28£	0.33	0.52	0.44	0.25	0.17	0.53	0.34	0.48
Deschampsia cespitosa	0.13£	0.16£	0.22£	0.25£	0.30	0.23	0.20	0.15	0.18	0.19	0.31	0.26
Festuca rubra	0.19£	0.16£	0.17£	0.16£	0.25	0.21	0.30	0.19	0.24	0.27	0.28	0.24
Holcus lanatus	0.29	0.37	0.25	0.26	0.55	0.25	0.23	0.33	0.19	0.14	0.29	0.50
Lolium perenne	0.19£	0.26	0.22£	0.22£	0.40	0.23	0.47	0.17	0.18	0.72	0.27	0.41
Phleum pratense	0.15£	0.15£	0.17£	0.11£	0.30	---	---	0.12	0.11	0.16	0.26	0.30
Poa spp.	---	---	---	---	---	0.50	0.24	0.14	0.20	0.22	0.32	0.63
Mean grasses	0.21£	0.20£	0.17£	0.20£	0.33	0.37	0.29	0.20	0.18	0.29	0.30	0.38

(continued)

* Less than 0.30 % , requirement for cattle and sheep
\+ Less than 0.56 % , requirement for deer except winter
£ Less than 0.25 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.3 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	0.56	0.61	0.62	0.73	---	0.38
Ranunculus spp.	---	---	---	---	0.40	0.49	0.51	0.36	0.48	0.66	0.30	0.46
Taraxacum officinale	---	---	---	---	0.32	0.47	---	---	---	0.29	0.35	0.44
Trifolium repens	---	---	---	---	0.48	0.22	0.17	0.26	0.31	0.31	0.36	0.35
Urtica dioica	---	---	---	---	0.84	0.94	0.63	0.33	0.60	0.22	0.71	0.67
Mean forbs	---	---	---	---	0.51	0.53	0.47	0.39	0.50	0.44	0.43	0.46
Rubus spp.	0.23£	0.22£	0.15£	0.26	---	---	0.22	0.15	0.19	0.18	---	---
Taxus baccata	0.34	0.23£	0.23£	0.19£	0.14	0.14	0.10	0.43	0.49	0.29	0.23	0.29
Moss	0.23£	0.22£	0.19£	0.21£	0.13	0.17	0.22	0.23	0.25	0.30	0.26	0.26
Broad leaved trees	0.29	0.29	0.29	0.29	0.29	0.36	0.36	0.36	0.36	0.20	0.20	0.20
Mast	0.13£											

* Less than 0.30 % , requirement for cattle and sheep
\+ Less than 0.56 % , requirement for deer except winter
£ Less than 0.25 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.4 Calcium : Phosphorus ratio in principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis	1.14	2.33	1.50	1.56	1.88	0.86*	1.96	2.37	2.72	1.79	1.03	0.74*
Cynosurus cristatus	2.21	2.15	1.58	1.17	1.55	1.91	1.92	4.00	3.54	2.33	1.48	0.90*
Dactylis glomerata	3.13	1.58	1.24	1.14	1.21	0.60*	0.73*	0.68*	2.65	0.60*	1.18	0.54*
Deschampsia cespitosa	1.38	1.06	0.86*	0.84*	1.33	1.04	2.05	2.67	2.94	1.42	0.61*	0.92*
Festuca rubra	2.05	2.13	2.06	1.56	2.28	1.57	1.00	2.11	2.04	2.52	2.61	1.92
Holcus lanatus	1.41	0.97*	1.32	1.08	0.75*	0.65*	1.37	2.00	2.11	1.86	1.00	0.64*
Lolium perenne	1.95	0.96*	1.32	1.14	0.93*	1.87	0.83*	3.89	2.11	0.47*	1.22	0.66*
Phleum pratense	1.80	2.27	1.59	1.91	1.17	---	---	5.58+	3.91	1.81	1.96	2.13
Poa spp.	---	---	---	---	---	0.68*	1.50	3.70	2.10	2.64	2.59	1.05
Mean grasses	1.57	1.50	1.47	1.25	1.30	0.92*	1.34	2.70	2.50	1.34	1.47	0.97*

(continued)

* Ratio below than 1:1
\+ Ratio above 5:1 , but below 7:1
£ Ratio above 7:1
--- No sample

Table 6.2.4 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	1.79	2.02	1.52	1.29	---	1.68
Ranunculus spp.	---	---	---	---	3.80	1.55	2.16	4.72	2.90	1.68	3.73	1.54
Taraxacum officinale	---	---	---	---	3.16	2.15	---	---	---	4.34	2.54	1.61
Trifolium repens	---	---	---	---	3.12	5.59	6.00+	5.35+	4.23+	4.77	2.69	1.97
Urtica dioica	---	---	---	---	2.69	2.02	4.06	8.85£	3.45	14.95£	5.95+	5.91+
Mean forbs	---	---	---	---	3.08	2.32	3.02	4.64	2.86	3.68	4.19	3.20
Rubus spp.	4.22	4.23	5.07+	3.62	---	---	3.05	4.47	3.84	4.28	---	---
Taxus baccata	2.09	2.74	3.26	3.32	6.43+	4.71	6.60+	1.19	1.00	2.17	2.61	2.41
Moss	1.34	1.64	2.11	1.52	4.00	2.59	1.91	3.35	2.40	1.47	2.69	2.81
Broad leaved trees	4.21	4.21	4.21	4.21	4.21	2.08	2.08	2.08	2.08	3.65	3.65	3.65
Mast	0.92*											

* Ratio below than 1:1
\+ Ratio above 5:1 , but below 7:1
£ Ratio above 7:1

--- No sample

Table 6.2.5 Potassium content, percent dry matter, of principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis	0.91	0.65	0.56	0.65	1.36	3.08	3.06	3.07	2.13	1.96	2.14	1.76
Cynosurus cristatus	0.62	0.46	0.25	0.85	2.07	1.62	2.34	1.18	1.08	1.08	1.15	1.99
Dactylis glomerata	1.11	0.86	1.16	2.09	2.83	2.91	3.72	3.17	3.21	3.00	2.55	3.21
Deschampsia cespitosa	0.82	0.77	1.08	1.31	2.01	1.98	1.89	1.67	1.26	1.45	1.97	1.83
Festuca rubra	1.05	0.95	0.95	0.61	1.78	1.85	3.01	2.42	1.62	1.73	2.53	2.45
Holcus lanatus	2.30	1.79	1.91	1.42	2.99	3.25	2.62	2.71	1.60	1.95	2.26	3.04
Lolium perenne	1.13	1.20	1.13	1.06	2.52	1.33	3.33	1.75	1.78	2.59	1.35	2.52
Phleum pratense	0.77	0.72	0.59	0.33	2.00	---	---	1.73	1.20	1.17	1.30	1.53
Poa spp.	---	---	---	---	---	3.02	2.95	2.54	2.59	1.89	2.57	2.98
Mean grasses	1.27	0.93	0.85	1.04	2.20	2.12	2.78	2.06	1.66	1.87	1.98	2.37

(continued)

* Less than 0.80 % , requirement for cattle and sheep
\+ Less than 0.50 % , requirement for deer except winter
£ Less than 0.25 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.5 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	1.74	1.49	1.15	2.37	---	1.95
Ranunculus spp.	---	---	---	---	2.80	2.88	3.14	2.46	2.04	3.04	2.91	2.44
Taraxacum officinale	---	---	---	---	2.99	3.38	---	---	---	3.16	2.61	2.92
Trifolium repens	---	---	---	---	2.04	2.47	2.72	1.49	1.80	1.90	2.35	2.34
Urtica dioica	---	---	---	---	2.81	2.98	3.03	2.69	3.11	3.13	3.03	2.74
Mean forbs	---	---	---	---	2.65	2.93	2.66	2.03	2.03	2.72	2.73	2.48
Rubus spp.	1.05	0.94	0.86	1.30	---	---	1.31	1.13	0.87	0.85	---	---
Taxus baccata	1.65	1.77	0.86	1.14	0.71	0.86	0.86	2.44	2.39	2.03	1.95	1.58
Moss	1.02	0.89	0.77	0.70	0.94	0.85	0.95	1.10	1.21	1.27	1.28	1.16
Broad leaved trees	0.16£	0.16£	0.16£	0.16£	0.16£	1.38	1.38	1.38	1.38	0.98	0.98	0.98
Mast	1.28											

* Less than 0.80 % , requirement for cattle and sheep
\+ Less than 0.50 % , requirement for deer except winter
£ Less than 0.25 % , requirement for deer during winter (December to March)
--- No sample

Table 6.2.6 Sodium content, percent dry matter,of principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis	0.09*	0.17*	0.14*	0.09*	0.13	0.14	0.18	0.13	0.16	0.17	0.11	0.14
Cynosurus cristatus	0.09*	0.11*	0.12*	0.08*	0.13	0.57	0.28	0.43	0.17	0.12	0.12	0.13
Dactylis glomerata	0.08*	0.16*	0.17*	0.08*	0.07	0.19	0.20	0.21	0.12	0.17	0.12	0.22
Deschampsia cespitosa	0.05*	0.06*	0.06*	0.03*	0.06	0.01	0.08	0.09	0.02	0.04	0.04	0.06
Festuca rubra	0.09*	0.17*	0.17*	0.05*	0.06	0.02	0.17	0.08	0.03	0.11	0.15	0.10
Holcus lanatus	0.16*	0.14*	0.19	0.09*	0.15	0.04	0.20	0.44	0.20	0.19	0.14	0.16
Lolium perenne	0.15*	0.14*	0.14*	0.12*	0.15	0.19	0.34	0.65	0.24	0.16	0.11	0.15
Phleum pratense	0.07*	0.10*	0.11*	0.06*	0.11	---	---	0.12	0.01	0.10	0.10	0.12
Poa spp.	---	---	---	---	---	0.05	0.09	0.18	0.72	0.21	0.17	0.10
Mean grasses	0.10*	0.13*	0.13*	0.08*	0.11	0.13	0.18	0.23	0.17	0.14	0.12	0.13

(continued)

* Less than 0.18 % , requirement for cattle , sheep and deer

--- No sample

Table 6.2.6 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	0.85	1.34	0.88	0.65	---	0.33
Ranunculus spp.	---	---	---	---	0.37	0.11	0.34	0.46	0.67	0.49	0.37	0.28
Taraxacum officinale	---	---	---	---	0.30	0.04	---	---	---	0.10	0.05	0.38
Trifolium repens	---	---	---	---	0.15	0.08	0.29	0.44	0.46	0.46	0.26	0.26
Urtica dioica	---	---	---	---	0.05	0.01	0.06	0.01	0.05	0.13	0.55	0.51
Mean forbs	---	---	---	---	0.22	0.06	0.39	0.56	0.52	0.37	0.31	0.35
Rubus spp.	0.04*	0.05*	0.06*	0.06*	---	---	0.01	0.02	0.05	0.04	---	---
Taxus baccata	0.12*	0.64	0.51	0.43	0.49	0.11	0.23	0.28	0.31	0.42	0.38	0.38
Moss	0.08*	0.10*	0.06*	0.04*	0.08	0.01	0.06	0.11	0.11	0.09	0.13	0.06
Broad leaved trees	0.08*	0.08*	0.08*	0.08*	0.08*	0.05	0.05	0.05	0.05	0.03	0.03	0.03
Mast	0.04*											

* Less than 0.18 % , requirement for cattle , sheep and deer

--- No sample

Table 6.2.7 Magnesium contents, percent dry matter, of principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis	0.10	0.13	0.10	0.11	0.16	0.16	0.25	0.22	0.03	0.17	0.16	0.14
Cynosurus cristatus	0.11	0.11	0.09	0.10	0.16	0.17	0.17	0.15	0.03	0.12	0.11	0.11
Dactylis glomerata	0.15	0.14	0.12	0.17	0.13	0.17	0.21	0.23	0.03	0.22	0.16	0.13
Deschampsia cespitosa	0.08	0.09	0.10	0.11	0.12	0.13	0.12	0.10	0.02	0.12	0.11	0.09
Festuca rubra	0.14	0.13	0.14	0.11	0.11	0.13	0.16	0.11	0.03	0.15	0.15	0.09
Holcus lanatus	0.14	0.14	0.13	0.11	0.15	0.14	0.15	0.17	0.03	0.11	0.14	0.13
lolium perenne	0.13	0.11	0.12	0.12	0.13	0.14	0.19	0.18	0.04	0.16	0.13	0.11
Phleum pratense	0.09	0.10	0.10	0.09	0.10	---	---	0.22	0.02	0.11	0.15	0.13
Poa spp.	---	---	---	---	---	0.17	0.15	0.19	0.13	0.19	0.32	0.16
Mean grasses	0.12	0.12	0.11	0.12	0.13	0.14	0.17	0.21	0.05	0.15	0.16	0.12

(continued)

* Less than 0.20 % , requirement for cattle and sheep
£ Less than 0.06 % , requirement for deer
--- No sample

Table 6.2.7 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	0.42	0.51	0.58	0.51	---	0.24
Ranunculus spp.	---	---	---	---	0.18	0.19	0.26	0.75	0.30	0.33	0.44	0.20
Taraxacum officinale	---	---	---	---	0.23	0.26	---	---	---	0.49	0.39	0.24
Trifolium repens	---	---	---	---	0.24	0.22	0.24	0.58	0.30	0.13	0.27	0.18
Urtica dioica	---	---	---	---	0.33	0.42	0.47	0.83	0.43	0.50	0.75	0.54
Mean forbs	---	---	---	---	0.25	0.27	0.35	0.67	0.40	0.39	0.46	0.28
Rubus spp.	0.31	0.29	0.29	0.20	---	---	0.34	0.70	0.35	0.35	---	---
Taxus baccata	0.18	0.15	0.23	0.19	0.16	0.12	0.11	0.03	0.15	0.16	0.16	0.14
Moss	0.18	0.17	0.17	0.15	0.13	0.14	0.15	0.05	0.22	0.23	0.21	0.14
Broad leaved trees	0.13	0.13	0.13	0.13	0.13	0.20	0.20	0.20	0.20	0.21	0.21	0.21
Mast	0.06£											

* Less than 0.20 % , requirement for cattle and sheep
£ Less than 0.06 % , requirement for deer
--- No sample

Table 6.2.8 *In vivo* dry matter digestibility (%, estimated) of principal forage species for herbivores.

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrostis tenuis	41.5*	36.6£	40.9*	41.3*	60.4	68.2	63.8	46.9	57.0	40.1	51.2	61.5
Cynosurus cristatus	33.7£	34.3£	37.8£	47.1*	71.9	69.8	59.2	42.5	54.3	46.6	41.9	64.5
Dactylis glomerata	43.6*	40.3*	56.6	60.9	75.8	74.2	64.7	43.4	56.8	65.0	50.0	73.4
Deschampsia cespitosa	20.3+	24.0+	46.8*	40.4*	72.7	67.8	56.5	48.4	43.4	47.7	43.2	53.8
Festuca rubra	39.2£	40.1*	39.8*	42.4*	73.9	65.4	61.8	58.2	59.3	50.1	56.4	60.4
Holcus lanatus	39.5*	53.4	67.5	53.4	71.1	71.0	61.2	45.6	60.5	49.5	51.2	76.6
lolium perenne	44.0*	46.4*	47.1*	51.2	72.4	74.4	69.4	64.7	68.7	64.2	50.9	69.4
Phleum pratense	45.6*	43.4*	49.8	39.1£	57.8	---	---	43.9	59.4	52.5	48.2	55.3
Poa spp.	---	---	---	---	---	70.0	60.4	38.8	73.9	46.4	62.8	72.0
Mean grasses	38.5£	39.8	47.5	47.0	69.5	69.8	61.8	47.7	58.2	51.3	50.6	65.2

(continued)

* Less than 50.0 % ,but more than 40.0 %
£ Less than 40.0 % ,but more than 30.0 %
\+ Less than 30.0 %
--- No sample

Table 6.2.8 (continued)

Plant species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Prunella vulgaris	---	---	---	---	---	---	50.9	57.6	58.5	65.9	---	68.1
Ranunculus spp.	---	---	---	---	80.2	58.0	65.8	69.1	70.2	70.7	71.9	65.2
Taraxacum officinale	---	---	---	---	71.2	69.0	---	---	---	68.2	73.0	73.0
Trifolium repens	---	---	---	---	70.6	77.6	70.0	75.7	72.6	73.8	75.1	76.7
Urtica dioica	---	---	---	---	75.7	72.5	70.3	64.3	71.9	68.6	67.7	75.4
Mean forbs	---	---	---	---	74.4	69.3	64.2	66.7	68.3	69.5	71.9	71.7
Rubus spp.	45.0*	44.3*	42.4*	43.2*	---	---	79.4	41.1	22.8	48.5	---	---
Taxus baccata	49.8	51.4	52.7	48.7*	55.7	57.5	58.0	56.7	58.5	47.6	47.6	57.0
Moss	14.1+	13.0+	24.1+	19.4+	35.9£	34.2£	31.0£	38.2£	38.6£	40.2*	31.3£	31.6£
Broad leaved trees	19.7+	19.7+	19.7+	19.7+	19.7+	42.7*	42.7*	42.7*	42.7*	42.7*	42.7*	42.7*
Mast	65.2											

* Less than 50.0 % ,but more than 40.0 %
£ Less than 40.0 % ,but more than 30.0 %
\+ Less than 30.0 %
--- No sample

6.3.3 Total Diet Quality

Mean dietary levels (% dry matter) of nutrients for herbivores are shown in Tables 6.3.1 to 6.3.8. Asterisk marks in the tables show diets of a certain herbivore deficient in that nutrient.

Crude protein: Crude protein content (Table 6.3.1) of the diet of fallow bucks and does during winter months was above the minimum level required for maintenance (> 7 %) but lower than the level required for maximum growth (< 13%). Minimum CP levels were in February, after which a slight increase was noticed. CP levels were less than that required for maximum growth (13 %) in July and August for the bucks and from June to August for the does. For other months dietary CP levels were higher than recommended. Diets of cattle were marginally deficient in CP in July and August (< 10.7%), and again in October when the CP requirement was increased because of suckling calves (<13%). Diets of sheep were also marginally deficient in July (10.53 % as against 10.7 % required level).

Calcium: Ca was deficient only marginally in the diet of bucks in November (Table 6.3.2), when they were rutting.

Phosphorus: P was deficient in the diet of bucks and does (Table 6.3.4) in February and in all the months from April to November. Diets of cattle were deficient in P in July, August and October; and those of sheep in July and August.

Ca:P ratio: Ca:P ratio in all the diets in all months of the year was within the range 1:1 to 5:1 (Table 6.3.4). The ratio was higher than the optimum 1.3:1 and never more than 3.4:1.

Potassium: K content of the diets of all herbivores was always higher than that recommended (Table 6.3.5).

Sodium: Na was deficient in the diet of bucks in December, March,

Table 6.3.1 Mean dietary levels, percent dry matter, of Crude protein in the diet of herbivores.

Months	Bucks	Does	Cattle	Sheep
October 1982	10.20	10.37	---	---
January 1983	10.58	10.83	---	---
February	9.38	9.29	---	---
March	9.82	10.48	---	---
April	14.69	14.31	---	12.90
May	14.20	14.31	13.59	13.14
June	14.12	11.68£	13.44	13.59
July	11.61£	12.37£	10.12*	10.53*
August	11.45£	11.63£	10.53*	11.25
September	13.89	13.55	11.47	13.07
October	13.15	13.92	12.44£	---
November	14.05	17.75	16.27	---

* Less than required 10.7 % for sheep and cattle.

£ Less than required 13.0 % for bucks,does,and lactating cattle in October and November.

--- Cattle/sheep not present on the range.

Table 6.3.2 Mean dietary levels, percent dry matter, of Calcium in the diet of herbivores.

Months	Bucks	Does	Cattle	Sheep
October 1982	0.58	0.56	---	---
January 1983	0.59	0.50	---	---
February	0.60	0.60	---	---
March	0.52	0.61	---	---
April	0.80	0.70	---	0.75
May	0.61	0.64	0.62	0.58
June	0.82	0.66	0.67	0.60
July	0.87	0.76	0.69	0.68
August	0.63	0.58	0.54	0.60
September	0.62	0.63	0.46	0.55
October	0.57	0.87	0.58	---
November	0.55*	0.98	0.66	---

* Less than required 0.60 % for deer.

£ Less than required 0.43 % for cattle and for deer during winter.

£ Less than required 0.30 % for sheep.

--- Cattle/sheep not present on the range.

Table 6.3.3 Mean dietary levels, percent dry matter, of Phosphorus in the diet of herbivores.

Months	Bucks	Does	Cattle	Sheep
October 1982	0.24	0.25	---	---
January 1983	0.23	0.24	---	---
February	0.19£	0.21£	---	---
March	0.26	0.27	---	---
April	0.31*	0.30*	---	0.29
May	0.35*	0.37*	0.34	0.31
June	0.39*	0.26*	0.37	0.35
July	0.26*	0.29*	0.23£	0.21£
August	0.27*	0.27*	0.22£	0.25£
September	0.35*	0.39*	0.32	0.37
October	0.27*	0.33*	0.27£	---
November	0.30*	0.40*	0.32	---

* Less than required 0.56 % for deer from April to November.

£ Less than required 0.25 % for deer from December to March.

£ Less than required 0.31 % for cattle.

£ Less than required 0.28 % for sheep.

--- Cattle/sheep not present on the range.

Table 6.3.4 Ca:P ratio in the diet of herbivores.

P=1

Months	Bucks	Does	Cattle	Sheep
October 1982	2.42	2.24	---	---
January 1983	2.57	2.08	---	---
February	3.16	2.86	---	---
March	2.00	2.26	---	---
April	2.58	2.33	---	2.59
May	1.74	1.73	1.82	1.87
June	2.10	2.54	1.81	1.71
July	3.35	2.62	3.00	3.24
August	2.33	2.15	2.45	2.40
September	1.77	1.62	1.44	1.49
October	2.11	2.64	2.15	---
November	1.83	2.45	2.06	---

* Optimum =1.3:1.0

Table 6.3.5 Mean dietary levels, percent dry matter, of Potassium in the diet of herbivores.

Months	Bucks	Does	Cattle	Sheep
October 1982	1.15	1.23	---	---
January 1983	1.04	1.14	---	---
February	0.72	0.76	---	---
March	0.88	1.03	---	---
April	1.98	1.93	---	1.61
May	2.24	2.16	2.02	1.90
June	2.78	1.98	2.59	2.58
July	2.10	2.04	2.06	2.03
August	1.83	1.72	1.76	1.70
September	1.85	1.99	1.84	1.88
October	1.68	2.10	1.58	---
November	1.87	2.26	1.82	---

* Less than required 0.80 % for cattleand sheep.

$ Less than required 0.50 % for deer and sheep.

Table 6.3.6 Mean dietary levels, percent dry matter, of Sodium in the diet of herbivores.

Months	Bucks	Does	Cattle	Sheep
October 1982	0.11*	0.13*	---	---
January 1983	0.20	0.19	---	---
February	0.18	0.21	---	---
March	0.11*	0.19	---	---
April	0.17*	0.16*	---	0.15*
May	0.15*	0.12*	0.12*	0.12*
June	0.27	0.22	0.26	0.24
July	0.36	0.30	0.35	0.34
August	0.24	0.19	0.22	0.21
September	0.15*	0.20	0.15*	0.15*
October	0.12*	0.20	0.13*	---
November	0.15*	0.24	0.19	---

* Less than required 0.18 %.

Table 6.3.7 Mean dietary levels, percent dry matter, of Magnesium in the diet of herbivores.

Months	Bucks	Does	Cattle	Sheep
October 1982	0.17	0.16	---	---
January 1983	0.17	0.15	---	---
February	0.18	0.17	---	---
March	0.14	0.16	---	---
April	0.15	0.15	---	0.14
May	0.18	0.19	0.18£	0.17
June	0.24	0.18	0.22	0.21
July	0.30	0.25	0.25	0.23
August	0.12	0.11	0.08£	0.12
September	0.19	0.20	0.16£	0.19
October	0.18	0.24	0.18£	---
November	0.14	0.20	0.16£	---

£ Less than required 0.20 % for cattle.
Less than required 0.06 % for deer and sheep.

Table 6.3.8 Mean dietry levels of Dry Matter Digestibility (IVDMD, %, estimated *in vivo*) in the diet of herbivores.

Months	Bucks	Does	Cattle	Sheep
October 1982	40.77*	38.86*	---	---
January 1983	39.45*	40.44*	---	---
February	40.16*	40.62*	---	---
March	39.11*	41.80*	---	---
April	63.92	61.62	---	55.08
May	64.64	60.94	61.20	59.88
June	64.49	58.63	59.23	58.32
July	54.96	54.20	52.21	55.00
August	60.86	56.96	60.46	59.46
September	51.90	55.06	50.48	52.17
October	48.36*	55.40	45.26£	---
November	58.80	65.36	54.32	---

* £ Less than optimum.

April and from September to November (Table 6.3.6). Sodium was also below the required limits in the diets of does in December, April and May. The diets of cattle contained sodium less than that required in May, September and October and those of sheep in April, May and September.

Magnesium: Mg was deficient only in cattle diets in August, September and November, and marginally so in May and October (Table 6.3.7).

IVDMD: Diets of fallow bucks and does had a digestibility co-efficient of about 40 % in the months from December-March, much less than the required levels (50 %) (Table 6.3.8). IVDMD of the diets of cattle in October was 45.26 %, which is less than the optimum. Incidently this is the calving time as well, and a diet with low digestibility co-efficient could mean a nutritional deficiency.

6.4 DISCUSSION

A general decrease in the nutrient level of plants with advancing maturity was evident. Crude protein contents of grasses decreased from 15.23 % in April to 9.07 % in July and that of forbs from 20.16 % in April to 17.09 % in July. Troelsen (1969, in Litt.) also reported a comparatively rapid decrease in CP content of grasses as compared with that of forbs. Jefferies and Rice (1969) also showed a decrease in CP content of grasses from short- grass prairies from 12.8 - 19.6 % in early June to 3.4 - 7.9 % in late August. A general decrease in protein levels of plants with advancing maturity has been reported by Hagen (1953), Bissel and Strong (1955), Rogers and Box (1967), Kamstra (1973), Rama Rao *et al* (1973), Cogswell and Kamstra (1976), Milner and Gwynne (1974), Siewerdt and Holt (1975), Stubbendiek and Foster (1978), Everitt and Gonzalez (1981), Gonzalez and Everitt (1982), Krysl *et al*. (1984), and Leslie *et al* (1984). Higher nutritional concentration of forbs than grasses as determined in this study has also been reported by Reid *et al* (1959), Kilcher and Heinricks (1974),

and Krysl *et al*(1984).

Calcium levels in grasses were generally less than the required levels for maximum growth but were adequate for maintenance (0.30 %, Magruder *et al* 1957). Ca levels in forbs were, however, always higher than the required levels for maximum growth. Short (1971) for black-tailed deer, and Krysl *et al* (1984) for cattle and horses also reported the same findings. Adequacy of calcium in food plants was shown for white-tailed deer by Everitt and Gonzalez (1981), and for cattle by Gonzalez and Everitt (1982), both from south Texas plains. Milner and Gwynne (1974) reported Ca levels in the vegetation at Hirta Island which could be considered as adequate for Soay sheep.

Phosphorus was generally deficient in grasses, whereas P in forbs, for most parts of the year, was adequate for growth, and for other times, was marginal for maintenance. P has been reported to be deficient in all the vegetation for Soay sheep (Milner and Gwynn 1974) and for white- tailed deer (Gonzalez and Everitt 1982). The deficiency was also reported to be more in grasses than in forbs (Everitt and Gonzalez 1981; Krysl *et al* 1984).

Ca:P ratio in this study, though wide was generally within the limits set by Wise *et al* (1963) (7: 1) and Owens and Gill (1979) (5: 1). Wider than 7:1 ratios have been reported by Everitt and Gonzalez (1981) and Krysl *et al*. (1984).

Potassium levels in grasses and forbs were much higher than required levels. Potassium has generally been reported to be adequate in vegetation (Milner and Gwynne 1974, Everitt and Gonzalez 1981, Gonzalez and Everitt 1982).

Sodium was generally deficient except for forbs which on average contained marginally adequate levels. Sodium has been found to be deficient in vegetation on other areas as well e.g., South Texas plains (Everitt and Gonzalez 1981, Gonzalez and Everitt 1982).

Everitt and Gonzalez (1981), also reported that forbs contained higher levels of Na than grasses. Milner and Gwynne (1974) however, reported Na levels which could be considered as adequate for Soay sheep.

Magnesium levels in vegetation were generally adequate for deer and sheep. Grasses, *Taxus* and moss (for spring and summer) were deficient in Mg content for cattle, whereas forbs contained higher concentrations of Mg. August was the only month when extremely low Mg levels were estimated in grasses. In case of severe Mg deficiency, and in the presence of excessive K, hypomagnesemic tetany could occur (McDonald *et al.* 1966). Other forage in August, however contained high levels of Mg, which could have rectified the situation.

Digestibility (IVDMD) of grass during winter was very low, it increased in spring, decreased in July but except for *Deschampsia* again increased with regrowth. Forbs at all the times were highly digestible. Moss had the lowest digestibility during winter, ranging from 13 % to 24 %. Even in other months digestibility varied from 32 - 40 %. Taxus and broad leaved trees also showed low digestibility co-efficients. Changes in IVDMD with advancing maturity have been recorded by Milner and Gwynne (1974), Everitt and Gonzalez (1981), Gonzalez and Everitt (1982), Leslie *et al.* (1984). Higher digestibility of forbs than grasses has been shown by Lewis *et al.* (1975) Everitt and Gonzalez (1981),and Krysl *et al.* (1984). Low digestibility of browse has also been reported by Hobbs *et al.* (1983), Krysl *et al.* (1984), and Leslie *et al.* (1984).

Dietary crude protein levels for deer during winter were much higher than the minimum required (7.0 %) level for maintenance. After March, dietary CP level increased but decreased again in June for the does and in July for bucks. CP levels in the diet increased again in September and peaked in November. During the period June - August for does and July, August for bucks, the CP levels were slightly below the recommended level (13 %) for best growth. Diets of cattle and sheep also showed the same pattern, and were marginally below the required

levels for sheep in July and for cattle in July, August and October. Very high dietary protein levels in spring months could have compensated for the deficiency encountered during summer months. Herbivores are also known to select more nutritious diets than these, simulated through clipping vegetation (Weir and Torell 1959, Klein 1962, Cable and Shumway 1966, Longhurst *et al.* 1968, Keisling *et al.* 1969, Schwartz *et al.* 1977), thus the estimates of CP made in this study may be lower than amounts actually consumed due to herbivores selecting plants or plant parts higher in nutrient content than those simulated by hand-picked food plant species.

Potassium and calcium levels in the diets of herbivores were adequate. Phosphorus levels in the diets of deer were inadequate for maintenance only in one month, whereas during summer, these were much below the recommended levels for maximum growth, but were above the maintenance levels. The diets of sheep and cattle were generally adequate in P but for some parts of the year were marginally deficient. To compensate the phosphorus deficiency animals are known to resort to alternative measures e.g. utilization of bones (Ross 1985), and coprophagy (Krysl *et al.* 1984). No such practice was seen on the park. Phosphorus deficiency affects the antler growth in bucks, (Magruder *et al.* 1957). Fallow bucks at Hopetoun have smaller than average sized antlers (Douglas-Menzies, pers. comm.). To avoid this deficiency P should be supplemented as a free choice.

Ca:P ratio in the diets of herbivores though was more than the optimum 1.3:1, but was not excessively wide, maximum being 3.16:1 for bucks in February.

The diets of all herbivores were generally adequate in sodium content. Marginal deficiency was obvious during some months, but it was not serious as salt was provided on the range free choice and animals could satisfy their requirements.

Mg was deficient in diets of cattle in August only. But the

cattle are fed Mg cobs on the range, therefore, this deficiency could not have been serious.

Amman *et al.* (1973) has reported that 50 % digestibility of forage plant species in the diet could be considered as adequate in supplying the animals with their required nutrients. Except for the winter months, when the dietary IVDMD was about 40 %, IVDMD was more than 50 % except for October when IVDMD of buck diets was marginally low and that of cattle diets was 45.3 %. IVDMD also followed the general growth pattern, i.e., an increase in spring, a decrease in summer and an increase in autumn. Lower digestibility in winter months may be just enough for maintenance. Krysl *et al.* (1984) reported a general rating of IVDMD values, developed by Urness and McCulloch (1973) as excellent (>50), good (40-50), fair (30-40) and poor (<30). On the basis of this categorisation, even during winter IVDMD for deer was good.

As is clear, the diets of herbivores on the range are not deficient in any nutrient except marginally in P, which could be rectified by free choice P feeding. Thus it is inferred that under the present system of management, the herbivores are obtaining optimum diets from the range and that multiple species grazing is not affecting the diet quality of the herbivores on the range.

6.5 SUMMARY

1. Hand plucked food plants were analysed for their nutritional contents.
2. Nutritional requirements for the growth of deer, cattle and sheep, and for the maintenance of deer during winter, as reported in literature were taken as standard, to determine the nutritional adequacy of forage in the herbivore diets.
3. Nutritional contents of food plants were the lowest in winter, increased with the advent of growing season in spring, decreased in summer and increased again with the regrowth

phase in early autumn.

4. Grasses in general were deficient in nutritional contents after spring, whereas forbs were generally adequate.
5. Moss was highly deficient in nutritional contents.
6. *Lolium* was the most nutritious grass species.
7. Potassium, calcium and magnesium were adequate in food plants. Phosphorus and sodium were generally deficient.
8. Total diet quality was determined by multiplying the proportions of food plant species in the diet with the percent nutritional contents and dividing them by 100, and adding all the sums together.
9. Diets were found adequate for nutritional contents except for phosphorus.
10 As the diets were not deficient in nutrition contents, it was suggested that multiple species grazing was not adversely affecting the diet quality of herbivores on the range.

7 FINAL DISCUSSION

7. FINAL DISCUSSION

The objective of this project was to compare the ecology of three types of herbivores sharing the same piece of rangeland. The primary interest centred on the use of a semi-domesticated deer species (in this case fallow deer) in such a system. Could the introduction of such a species into the system lead to an increase in the overall production of the system ? To approach this question I tried to determine whether or not the deer were utilizing resources not adequately used by the other herbivores.

A number of studies [Cliff (1939) on elk and mule deer in Oregon; Edwards (1942) on deer, cattle and sheep in Oregon; Cowan (1947) on deer, elk and sheep in Alberta; Longhurst *et al* (1952) on mule deer and cattle in California; Julander (1955, 1958) on deer, cattle and sheep in Utah; Culpin *et al* (1964, in litt., Nolan and Connolly 1977) on sheep and steer; Petrides and Swank (1965) on various ungulates in Uganda; Skovlin *et al* (1968) on deer, elk and cattle in California; Mackie (1970) on mule deer, elk and cattle in Missouri River Breaks Montana; Jarman (1971) on large mammals in Rhodesia; Anthony and Smith (1977) on mule deer and white-tailed deer in Arizona; Lucich and Hansen (1981) on mule deer and cattle in Colorado] have shown that where a rangeland is overstocked by a multi-species grouping of herbivores severe competition can occur between species. Therefore, it was important to establish that the situation at Hopetoun was not that of an overstocked range. This was done by examining the overall quality of the diet obtained by each group of herbivores on the range (Chapter 6). This showed that in general the diets of the animals were adequate for their requirements with the minor exceptions of phosphorus and sodium,. Therefore, it seems highly unlikely that the range was overstocked. Hopetoun was thus a suitable location in which to test the general idea.

A number of different aspects of the herbivores' ecology were examined, the most important being their selection of habitats and

vegetation types and their selection of specific food plants.

The selection of food plants will be discussed first. There were both significant similarities and significant differences in the diets of the different species. For all of them *Lolium* was the most important item in the diet. The analysis of the plant species available showed that *Lolium* was the highest quality grass available both in terms of nutritional content and digestibility (Tables6.2.1 - 6.2.8). The results of the vegetation survey conducted throughout the whole of the rangeland showed that *Lolium* was also the most frequently occurring grass species. Thus all the herbivores were utilizing most the commonest and most nutritious species of grass available to them. For this species it could, therefore, be argued that the deer were utilizing food that might otherwise have been available to the domestic stock. The same argument might apply to the next most frequently taken grass, *Festuca rubra*. However, one must at the same time examine whether or not the different herbivores grazed in the same areas within the park. It is possible that even though there was this large overlap in diet there might have been a spatial separation within the range. This will be looked at in detail later.

Considering the rest of the diet it is clear that there were substantial differences between herbivores. Taking the total diet into consideration, fallow does had the most diverse diet and sheep the least diverse. The indices of dietary similarity showed a wide divergence between species. In total fallow does overlapped to the extent of 63 % with sheep and 55 % with cattle. The comparable figures for fallow bucks were 69 % respectively. These differences in overall diet were the result of the deer taking different proportions of the available food species from the domestic stock and to a lesser extent by them utilizing species not used by the domestic stock. The most significant species used extensively by deer but little used by sheep and cattle were *Urtica*, *Taxus*, *Rubus*, and mast from *Quercus*. Some species were utilized extensively by the domestic stock but little used by the deer. The cattle especially were highly dependent

on *Holcus* which ranked 5th in importance in their diet. In sheep *Holcus* ranked 13th and in fallow bucks 15th but it did not feature at all in the top 20 species in fallow doe diets. Similarly *Anthoxanthum* was important for both cattle and sheep but not for the deer. Mosses were also taken in much more by cattle and sheep than by the deer but there must remain some doubt as to whether mosses were consumed accidentally or taken in deliberately.

These similarities and differences in diet must now be considered in relation to the distribution of the animals within the range. In this respect the biggest differences occurred between the sheep and the deer. Although there was clearly some degree of overlap in their preferred foraging areas, the sheep showed a distinct preference for the open grassland areas and the deer showed a preference for the areas with at least some degree of tree cover. Thus, although *Lolium* and *Festuca* were the most frequently taken plant species by sheep and deer, to a significant extent they were taken from different parts of the range by the two herbivores. Therefore, what at first seems to be a very large overlap in the utilization of food resources turns out to be much less so when this spatial aspect is also considered.

For deer and cattle there was a much greater overlap in preferred feeding areas so that there was less evidence of a subdivision of resources.

Preferential use of habitats has also been reported by other research workers. Colquhoun (1971) showed that red deer in Perthshire preferred shrub communities whereas hill sheep preferred to stay in open swards. Bullock (1982) documented the preferential use of grasslands in southern Scottish uplands by sheep as compared to goats which selected shrub communities more. Welch (1984) noted that the sheep in north eastern Scotland selected improved grasslands.

The evidence presented above strongly suggests that despite the clear degree of overlap between the deer and the domestic stock, in a

rangeland such as that at Hopetoun, where there is a mixture of woodland, parkland and open grass habitats, fallow deer can beneficially be added to the community of herbivores. The main factor in this is the way the deer made greater use of the tree covered areas than the other stock. One might not expect to find such clear separation on rangeland where the tree cover was significantly less.

It is interesting also to consider the information presented here on the foraging ecology of fallow deer, cattle and sheep in relation to general theories of herbivore nutritional ecology. Metabolic requirements of small bodied mammals make them more selective as compared to large bodied mammals as the former are considered to require greater concentrations of digestible energy (Moen 1973). They, therefore, tend to choose comparatively more digestible and nutritious diets (Bell 1971, Jarman 1971, Jarman and Sinclair 1979, Schwartz and Ellis 1981, Hobbs *et al* 1983). Fallow does which are of the lowest body weight in the present study consumed on average more forbs (more digestible and nutritious than grasses), and less grasses as compared to the other herbivores in the study area. They also consumed more mast and less moss. Cattle, the largest animals consumed least forbs.

Dudzinski and Arnold (1973), and Forbes (1982) have suggested on the basis of differences in mouth morphology and, therefore, in mechanics of grazing between cattle and sheep that sheep would be more selective than cattle. Sheep as compared to cattle have been reported to consume more forbs and less grasses (Cook *et al* 1967, Bedell 1968, Dudzinski and Arnold 1973), and more leaves and less stems (Van dyne and Heady 1965 (b), Dudzinski and Arnold 1973, Forbes 1982).

Different rumeno- reticulum - body weight relationships of fallow deer, sheep and cattle (14, 25 and 26.4 respectively) (Prins and Geelen 1971) also suggest that the fallow would have a high turnover rate of readily fermentable food stuff to meet energy requirements, thus requiring them to be more selective. Short (1964, 1966a) also

suggested that longer retention time of food materials in more capacious stomachs of sheep and cows are helpful in digesting the more refractive fibrous foods, not normally occurring in the diets of deer. Short and Remmenga (1965) and Short (1966 a)have also shown that cellulose digestion in white-tailed deer is rather limited, thus making them more selective of non-fibrous foods.

On the basis of rumen morphology and feeding habits, ruminants can be classified along a gradient of diet quality (Hoffmann and Stewart 1972, Hoffmann 1973): concentrate selectors - eating browse tips, forbs and new growth of grasses e.g., dik dik (*Madoqua kirki*), roe deer; intermediate feeders - more versatile feeders, grass or browse, adapting to season and local conditions e.g., Thomson's gazelle (*Gazella thomsoni*), domestic sheep (Squires 1982c), and roughage feeders - eating mostly grasses e.g., elk, African buffalo (*Syncerus caffer*), cattle and domestic sheep (Bullock 1982).

In the context of this study I suggest that fallow deer be classed as intermediate feeders (also reported by Van de Veen 1979), and cattle as true grazers. Sheep have been classed as roughage feeders by Van de Veen (1979) and Bullock (1982), and as intermediate feeders by Squire (1982c). In the present study, sheep and cattle though consumed equal amount of grasses, but the proportions of more digestible and nutritious grasses, i.e., *Lolium* and *Festuca*, were more in the diet of sheep. Sheep also consumed more forbs and less broad leaved tree foliage. On a parkland such as Hopetoun, which is predominantly a grassland, even minor differences, such as these would tend to lead to a conclusion that sheep are more selective as compared to cattle. Therefore, I would tend to classify sheep also as intermediate feeders.

Possibilities of future management and Research

A parkland such as Hopetoun Deer Park can have two different management alternatives, such as

i. Manage the area as a deer park only, or
ii. To continue the existing multiple species grazing system.

With an ever increasing demand for high quality meat, deer parks trading in venison are increasingly being established. Red deer and fallow deer are the two deer species which are being utilized for this purpose.

Fallow deer parks are popular in England and on the Continent (Yerex 1982), whereas only 4 farms in Scotland have fallow deer. Hopetoun deer park could afford a possibility of maintaining the area as the deer park only for fallow deer. The park contains all the necessary requirements for fallow deer - the required shelter, shaded habitats, and food plant species which can provide adequate diet for deer, and also the browse for the times of scarcity when they might have to fall back on it.

However, the area also has the habitat and food plant species which are preferred by other livestock. To eliminate other livestock from the park would mean, under utilization of those habitats e.g., grasslands, and an over-crowding in the habitats preferred by deer i.e., shaded areas, and may also lead to competition amongst the deer for favoured food plant species. The cattle and sheep do not use the range during winter, and if only the deer are kept on the range, they would be at higher stocking levels than at present, and would utilize the range all the year round. Whether the range could provide food and the habitat needed for the higher numbers during winter would have to be studied.

Under the present system of management, it appears, that the deer, cattle and sheep grazing together are thriving. There are no apparent signs of site deterioration, though in the absence of data on range condition trend, this is not possible to say with certainty. In my opinion, however, the system should be continued as such.

This suggestion leads to further thoughts of future research into the system. Hopetoun park, because of its proximity to Edinburgh University, and the ever helpful management executives presents with a great possibility of future research. A follow up study on the present project would greatly increase the understanding about the ecology of multiple species grazing. A few aspects of such a study could be :

i. The effect of environmental factors on the use of habitat types and grazing behaviour.

ii. Night time grazing and its effects on diurnal grazing behaviour.

iii. Social organization of three herbivores and its effect on their nutritional ecology.

iv. Range condition trend and changes in carrying capacity of the range at different standards of utilization.

v. Seasonal and yearly changes in the nutritional content of food plant species.

vi. Economic appraisal of the system.

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APPENDICES

Appendix 3.1 Utilization of habitat by the herbivores

Domains	Bucks		Does		Cattle		Sheep	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
OCTOBER 1982								
1	0	3	0	0	14	0	0	0
2	0	0	0	0	53	22	0	0
3	6	2	31	0	113	22	0	0
4	5	9	19	3	62	15	0	0
5	0	0	8	0	58	5	0	0
6	1	0	12	0	7	4	0	0
7	8	6	34	0	33	5	0	0
8	2	0	0	0	6	0	0	0
9	0	0	23	0	97	30	0	0
10	19	16	152	1	60	12	0	0
11	0	0	8	0	142	34	29	0
12	9	3	52	0	151	13	22	0
13	2	15	4	31	46	2	61	0
14	0	0	0	0	22	2	96	2
15	0	1	0	0	80	9	226	36
16	0	0	0	0	23	0	95	11
17	0	0	0	0	35	0	48	0
18	0	0	0	0	57	4	6	13
19	0	0	0	0	190	68	77	4
20	15	23	200	114	172	19	105	36
21	1	4	24	49	78	7	202	25
22	2	2	50	10	54	55	130	8
23	2	2	41	0	197	72	79	0
24	7	12	87	30	12	11	0	0
25	2	1	7	8	84	18	6	0
26	8	20	183	73	82	10	106	59
27	0	6	77	60	260	66	266	178
28	0	0	18	0	168	90	196	29
29	0	2	9	0	13	11	0	0
30	6	33	100	66	4	1	3	4
31	2	2	3	0	2	0	0	0
32	2	10	37	8	0	0	0	0

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle		Sheep*	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
NOVEMBER 1982								
1	0	0	5	0	12	0	0	0
2	2	0	0	0	12	0	0	0
3	0	1	15	0	38	2	0	0
4	3	1	13	0	16	0	0	0
5	1	0	5	0	25	30	0	0
6	0	0	0	0	0	0	0	0
7	8	5	51	15	4	3	0	0
8	1	0	0	0	0	0	0	0
9	3	0	48	3	65	8	0	0
10	9	1	122	24	0	0	0	0
11	0	0	0	0	25	0	0	0
12	0	0	8	0	20	0	0	0
13	9	1	36	3	42	4	0	0
14	0	0	0	0	24	0	0	0
15	3	0	2	0	41	14	0	0
16	0	0	0	0	1	2	0	0
17	0	0	0	0	1	0	0	0
18	0	0	4	0	22	3	0	0
19	0	0	0	0	0	0	0	0
20	3	11	50	26	88	7	0	0
21	4	2	1	0	79	4	0	0
22	0	1	0	0	6	13	0	0
23	0	0	3	0	61	14	0	0
24	1	0	5	0	6	1	0	0
25	0	0	0	0	12	6	0	0
26	19	21	3	5	42	6	0	0
27	21	3	42	1	58	0	0	0
28	4	0	0	0	25	0	0	0
29	0	4	0	0	7	0	0	0
30	11	17	40	31	6	1	0	0
31	1	1	1	6	4	0	0	0
32	8	0	17	8	0	0	0	0

* Sheep not present

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle*		Sheep*	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
DECEMBER 1982								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	10	2	21	27	0	0	0	0
11	0	0	0	0	0	0	0	0
12	2	0	6	0	0	0	0	0
13	3	12	17	13	0	0	0	0
14	0	0	0	0	0	0	0	0
15	7	3	32	32	0	0	0	0
16	2	0	10	0	0	0	0	0
17	18	0	59	0	0	0	0	0
18	14	0	33	2	0	0	0	0
19	0	0	0	0	0	0	0	0
20	17	1	76	16	0	0	0	0
21	11	4	33	18	0	0	0	0
22	2	0	8	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
26	5	0	21	0	0	0	0	0
27	20	0	67	0	0	0	0	0
28	43	3	134	35	0	0	0	0
29	9	2	46	8	0	0	0	0
30	11	11	44	49	0	0	0	0
31	0	1	0	14	0	0	0	0
32	0	0	6	2	0	0	0	0

* Cattle and sheep not present

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle*		Sheep+	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
JANUARY 1983								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	38	0
4	0	0	0	0	0	0	75	0
5	0	0	0	0	0	0	79	0
6	0	0	0	0	0	0	0	0
7	0	0	21	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	1	0	0	0	0	0	51	0
10	0	0	0	0	0	0	40	0
11	0	0	0	0	0	0	50	115
12	0	0	0	0	0	0	0	0
13	0	12	0	43	0	0	0	0
14	0	0	0	0	0	0	0	0
15	6	2	37	0	0	0	246	0
16	3	0	6	0	0	0	0	0
17	4	0	8	0	0	0	40	0
18	9	2	34	0	0	0	12	0
19	7	0	36	0	0	0	145	2
20	6	1	34	3	0	0	156	3
21	6	1	17	12	0	0	22	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	2	0	0	0	0	0	0	0
26	35	26	158	104	0	0	0	0
27	12	0	76	0	0	0	520	1
28	0	0	4	0	0	0	487	2
29	7	0	37	0	0	0	6	0
30	5	4	57	49	0	0	0	0
31	0	0	0	0	0	0	0	0
32	9	10	0	0	0	0	0	0

* Cattle not present

\+ Sheep present only for two days

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle*		Sheep*	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
FEBRUARY 1983								
1	0	1	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	6	0	0	0	0	0	0	0
5	3	1	19	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	14	17	120	123	0	0	0	0
8	0	0	0	0	0	0	0	0
9	1	0	18	0	0	0	0	0
10	19	8	85	23	0	0	0	0
11	0	0	0	0	0	0	0	0
12	6	1	21	2	0	0	0	0
13	6	1	13	8	0	0	0	0
14	0	0	7	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	6	24	56	74	0	0	0	0
21	5	0	29	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
26	5	0	8	21	0	0	0	0
27	31	23	69	25	0	0	0	0
28	6	6	42	41	0	0	0	0
29	5	0	9	16	0	0	0	0
30	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	2	4	0	0	0	0	0	0

* Cattle and sheep not present

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle*		Sheep*	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
MARCH 1983								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	3	3	0	0	0	0
8	0	0	5	0	0	0	0	0
9	0	0	15	0	0	0	0	0
10	6	0	19	0	0	0	0	0
11	0	12	12	41	0	0	0	0
12	0	12	26	40	0	0	0	0
13	17	2	84	3	0	0	0	0
14	0	0	0	0	0	0	0	0
15	6	0	8	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	7	23	26	44	0	0	0	0
18	0	0	0	0	0	0	0	0
19	1	11	20	56	0	0	0	0
20	9	23	53	70	0	0	0	0
21	1	11	12	34	0	0	0	0
22	6	0	20	0	0	0	0	0
23	37	35	104	109	0	0	0	0
24	4	0	13	0	0	0	0	0
25	12	0	45	6	0	0	0	0
26	46	55	145	157	0	0	0	0
27	6	0	20	0	0	0	0	0
28	1	0	28	0	0	0	0	0
29	6	0	21	0	0	0	0	0
30	3	12	2	38	0	0	0	0
31	2	0	0	0	0	0	0	0
32	0	0	6	10	0	0	0	0

* Cattle and sheep not present

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle		Sheep*	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
APRIL 1983								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	8	0	0	0
3	0	0	0	0	74	44	0	0
4	6	0	0	0	0	0	0	0
5	0	0	0	0	18	3	0	0
6	0	0	0	0	0	0	0	0
7	4	18	0	0	40	2	0	0
8	0	0	0	0	0	0	0	0
9	10	16	2	0	0	0	0	0
10	0	0	0	0	0	0	8	0
11	0	2	0	0	0	0	91	277
12	12	10	29	24	0	0	0	0
13	4	18	19	12	18	3	0	0
14	0	0	0	0	0	0	0	0
15	6	0	20	0	19	2	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	6	12	18	43	38	4	0	0
20	12	0	76	19	2	0	0	0
21	8	7	25	94	0	0	0	0
22	0	0	0	0	0	0	0	0
23	24	12	88	33	0	0	222	27
24	6	6	21	20	0	0	22	56
25	0	0	0	0	0	0	18	0
26	43	49	219	148	0	0	0	0
27	3	22	23	40	28	33	0	0
28	6	0	34	2	0	0	0	0
29	21	12	115	24	0	0	0	0
30	6	6	25	24	0	0	0	0
31	0	0	0	0	0	0	11	93
32	0	0	3	10	0	0	0	0

* Only rams present

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle		Sheep	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
MAY 1983								
1	0	0	0	0	6	0	0	0
2	0	4	0	0	15	0	0	0
3	0	0	0	0	45	35	131	0
4	8	3	0	0	22	20	25	0
5	9	3	13	3	58	119	0	0
6	3	0	21	0	17	0	0	0
7	12	44	46	37	63	13	0	0
8	40	49	0	0	0	0	0	0
9	12	0	17	15	79	56	46	0
10	5	4	40	5	61	27	0	0
11	4	0	2	0	71	10	391	137
12	0	1	20	44	40	32	396	669
13	6	0	103	87	36	4	117	149
14	0	0	11	0	2	0	234	5
15	3	0	0	0	19	21	437	50
16	0	0	0	0	0	2	139	0
17	0	0	20	0	30	0	121	26
18	0	0	13	1	48	4	211	0
19	0	0	0	0	45	77	389	50
20	9	7	56	115	68	47	382	478
21	4	0	14	0	1	10	720	109
22	1	0	13	89	30	33	145	126
23	3	0	51	11	81	1	606	385
24	1	4	63	10	2	0	10	0
25	18	12	47	0	2	10	38	0
26	25	5	91	85	43	6	552	120
27	0	0	18	10	25	1	950	538
28	0	0	0	0	30	35	505	700
29	9	3	92	120	28	6	17	202
30	0	0	16	13	1	0	71	171
31	0	0	0	0	3	0	0	0
32	0	1	0	0	0	0	0	0

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle		Sheep	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
JUNE 1983								
1	0	0	3	0	4	0	52	7
2	0	0	4	0	12	9	59	10
3	13	0	0	1	34	15	543	43
4	70	71	1	4	37	8	319	25
5	5	8	0	35	32	17	320	36
6	11	9	1	14	4	17	32	1
7	67	41	7	9	48	50	428	14
8	110	111	0	3	52	3	58	6
9	19	6	21	5	62	71	233	15
10	6	6	25	25	29	32	310	15
11	11	0	44	4	24	27	330	73
12	0	0	20	13	0	0	497	148
13	0	0	119	40	1	0	246	195
14	0	0	53	11	2	0	290	26
15	0	0	11	14	29	12	762	159
16	0	0	0	2	0	0	155	0
17	0	0	20	0	12	30	179	0
18	0	0	0	0	7	0	379	729
19	0	0	3	7	7	41	985	665
20	0	0	92	151	43	39	693	980
21	0	0	75	53	4	7	965	505
22	0	0	0	1	0	0	282	93
23	6	12	25	41	66	63	659	31
24	0	0	51	37	3	0	65	0
25	3	0	40	6	12	6	606	76
26	9	3	61	81	1	38	960	305
27	1	5	12	42	28	72	970	975
28	0	0	11	51	34	10	999	990
29	0	0	84	31	23	3	122	629
30	1	0	171	121	14	0	302	310
31	0	12	6	5	0	0	0	0
32	0	0	0	0	0	0	0	0

Appendix 3.1 Utilization of habitat by the herbivores.

(continued)

Domains	Bucks		Does		Cattle		Sheep	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
JULY 1983								
1	0	0	0	0	9	22	0	0
2	0	0	4	0	38	19	0	0
3	0	0	2	8	171	17	29	10
4	1	2	0	0	65	384	280	33
5	0	0	0	0	50	8	291	93
6	0	0	0	0	0	0	58	10
7	14	19	6	2	49	98	297	145
8	139	245	0	3	47	153	103	95
9	99	91	23	10	27	18	504	999
10	0	0	8	8	23	5	471	21
11	23	21	7	19	18	72	450	931
12	0	0	8	4	3	11	689	555
13	0	0	11	29	53	28	315	55
14	0	0	0	0	9	0	141	0
15	0	0	3	0	15	1	278	70
16	0	0	0	0	0	0	99	0
17	0	0	7	5	25	0	97	7
18	0	0	0	0	9	1	406	167
19	0	0	24	55	74	144	298	85
20	11	0	36	109	53	26	99	226
21	1	21	33	7	54	75	586	83
22	0	0	6	1	13	4	249	52
23	1	30	137	201	209	220	970	620
24	0	0	30	2	63	9	59	0
25	1	0	101	18	144	112	980	737
26	0	0	110	154	91	85	667	640
27	54	22	67	84	127	288	990	637
28	0	0	41	26	62	7	392	814
29	0	0	5	1	13	14	0	654
30	0	0	16	29	11	16	115	210
31	0	0	10	36	0	0	3	35
32	0	0	0	0	0	0	0	0

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle		Sheep	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
AUGUST 1983								
1	0	0	0	0	9	0	10	0
2	0	0	0	0	35	12	128	2
3	0	0	0	0	40	5	331	28
4	0	1	0	0	36	96	249	154
5	0	0	0	1	24	0	85	6
6	0	0	0	0	0	0	44	0
7	55	11	2	1	100	7	225	5
8	44	85	0	0	0	0	0	0
9	92	109	6	0	6	16	262	614
10	5	0	0	0	0	0	153	86
11	0	0	13	0	3	12	490	705
12	0	0	7	3	14	7	575	999
13	2	1	19	19	10	5	345	29
14	0	0	0	0	3	1	36	0
15	0	0	45	0	62	39	542	40
16	0	0	6	0	5	0	332	12
17	0	0	9	0	0	0	258	37
18	0	0	63	9	30	3	266	51
19	0	0	14	5	0	34	514	161
20	0	2	59	105	21	2	364	43
21	0	0	17	9	25	56	335	44
22	0	0	17	0	4	2	222	85
23	71	96	97	141	57	123	733	273
24	0	0	10	16	0	0	73	0
25	1	0	26	1	41	16	583	624
26	8	4	76	94	47	76	639	380
27	42	76	161	162	103	196	799	990
28	13	0	54	34	19	2	595	620
29	4	0	73	31	1	0	17	238
30	0	0	22	58	25	7	0	17
31	0	2	29	38	4	0	0	146
32	0	0	0	0	0	0	0	0

Appendix 3.1 Utilization of habitat by the herbivores

(continued)

Domains	Bucks		Does		Cattle*		Sheep	
	Grazing	Resting	Grazing	Resting	Grazing	Resting	Grazing	Resting
SEPTEMBER 1983£								
1	0	0	0	0	0	0	72	27
2	8	0	0	0	0	0	98	2
3	3	0	1	0	0	0	216	2
4	0	0	0	0	0	0	210	42
5	0	0	0	0	0	0	184	2
6	0	0	0	1	0	0	42	0
7	18	1	0	0	0	0	176	50
8	1	4	0	0	0	0	0	0
9	21	6	0	0	0	0	181	40
10	3	8	18	1	0	0	205	26
11	16	24	32	7	0	0	66	0
12	7	0	6	3	0	0	337	92
13	0	0	4	39	0	0	128	1
14	0	0	0	0	0	0	49	0
15	1	25	12	0	0	0	77	52
16	0	0	0	0	0	0	175	18
17	0	0	0	0	0	0	122	0
18	0	0	0	0	0	0	135	60
19	10	4	0	0	0	0	572	48
20	8	9	41	21	0	0	80	92
21	0	0	30	6	0	0	190	34
22	0	0	4	0	0	0	141	0
23	15	23	105	1	0	0	370	385
24	0	10	28	2	0	0	81	201
25	0	0	14	0	0	0	331	138
26	1	1	60	40	0	0	225	91
27	0	1	6	0	0	0	82	80
28	0	0	0	0	0	0	143	138
29	0	0	46	8	0	0	24	2
30	0	0	25	58	0	0	4	2
31	11	13	6	0	0	0	0	0
32	0	0	0	0	0	0	0	0

* Cattle not present

£ Data presented only for the first two weeks.

Appendix 4.1 Diurnal grazing behaviour in July 1983
Number of observations recorded on herbivores.
grazing or resting

Timespan	Bucks		Does		Cattle		Sheep	
(GMT)	G	R	G	R	G	R	G	R
0300-0600	34	72	116	69	210	309	695	2861
0601-0800	31	70	47	112	181	131	1388	651
0801-1000	54	51	72	100	77	268	802	1523
1001-1200	45	65	69	151	178	170	1062	1251
1201-1400	37	51	45	108	94	254	355	1422
1401-1600	25	61	86	91	145	187	702	1103
1601-1800	60	26	120	81	83	77	1434	389
1801-2000	29	57	110	63	251	91	1746	319
2001-2300	43	73	141	87	297	157	2545	450

G Grazing

R Resting

Each figure calculated from 5 days observations.

Appendix 4.2 Diurnal grazing behaviour in January 1983
Number of observation recorded on deer.
grazing or resting

Time span (GMT)	Bucks		Does	
	G	R	G	R
0801-100	28	4	127	18
1001-1200	21	19	105	65
1201-1400	26	14	116	49
1401-1600	24	14	146	24
1601-1800	13	7	51	34

0 G Grazing

R Resting

Each figure calculated from 4 days of observations.

Appendix 4.3 Seasonal grazing behaviour

Number of observations recorded on herbivores. grazing or resting

Months	Bucks		Does		Cattle		Sheep	
	G	R	G	R	G	R	G	R
October	99	172	1179	453	2375	607	1753	405
November	111	69	471	122	742	118	---	---
December	174	39	613	216	---	---	---	---
January	113	58	525	211	---	---	---	---
February	116	87	496	333	---	---	---	---
March	170	196	687	611	---	---	---	---
April	177	190	717	493	245	91	372	453
May	172	140	767	545	979	569	6633	3915
June	332	284	960	807	624	570	12800	7061
July	344	451	695	811	1525	1837	9916	7984
August	337	387	825	727	724	717	9205	6389
September	123	129	438	187	---	---	4716	1625

G Grazing

R Resting

-- Cattle/sheep not present on the range

Appendix 4.4 Diurnal habitat use by herbivores for grazing by time of day in July 1983, (numbers).

Time span	Bucks			Does			Cattle			Sheep		
(GMT)	h1	h2	h3	h1	h2	h3	h1	h2	h3	h1	h2	h3
0300-0600	0	0	34	23	64	25	16	144	50	159	20	516
0601-0800	0	31	0	21	17	9	10	82	89	13	1123	252
0801-1000	12	32	10	12	42	18	0	44	33	20	694	88
1001-1200	11	34	0	21	38	10	73	45	60	8	642	412
1201-1400	0	37	0	0	34	11	0	68	26	3	162	190
1401-1600	0	25	0	7	28	51	12	121	12	54	437	211
1601-1800	0	44	16	58	0	62	15	36	32	283	682	469
1801-2000	0	29	0	15	45	50	54	113	84	81	878	787
2001 2300	0	32	11	32	53	56	53	150	94	156	1331	1058

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

Each figure calculated from 5 days observations.

Appendix 4.5 Diurnal habitat use by herbivores for resting by time of day in July 1983, (numbers).

Time span	Bucks			Does			Cattle			Sheep		
(GMT)	h1	h2	h3	h1	h2	h3	h1	h2	h3	h1	h2	h3
0300-0600	0	72	0	38	31	0	29	175	105	333	490	2038
0601-0800	0	48	22	35	71	6	12	57	62	214	170	267
0801-1000	0	51	0	39	61	0	0	168	100	206	1226	91
1001-1200	0	65	0	52	81	18	41	106	60	291	566	400
1201-1400	0	51	0	6	55	47	3	104	147	409	925	88
1401-1600	0	61	0	10	54	27	1	94	92	127	605	371
1601-1800	0	21	5	16	18	47	2	70	5	69	198	122
1801-2000	0	57	0	8	23	32	10	78	3	69	148	102
2001 2300	0	73	0	4	35	48	19	127	11	27	174	249

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

Each figure calculated from 5 day observations.

Appendix 4.6 Observations on the use of habitat types for grazing or resting in relation to time of day in January 1983.

a. Grazing

Time span (GMT)	Bucks			Does		
	h1	h2	h3	h1	h2	h3
0801-1000	7	14	7	61	51	15
1001-1200	3	7	11	25	48	32
1201-1400	9	2	15	44	8	64
1401-1600	3	14	7	4	69	73
1601-1800	3	9	1	0	41	10

b. Resting

0801-1000	0	4	0	0	18	0
1001-1200	5	13	1	27	38	0
1201-1400	4	8	2	22	27	0
1401-1600	11	1	2	24	0	0
1601-1800	6	1	0	22	12	0

h1 Tree groves

h2 Shaded areas

h3 Grassland areas

Each figure calculated from 4 days observations.

Appendix 5.1 Botanical composition, percent, of the diets of culled fallow bucks.
Comparison of rumenal contents and rectal faecal pellet analysis.

Buck number	1		2		3		4	
Plant species	Rum	Rec	Rum	Rec	Rum	Rec	Rum	Rec
Agrostis spp.	4.5	5.5	7.5	12.0	4.5	3.0	3.0	3.0
Alopecurus pratensis	1.0	2.0	0.5	0.5	0	0	0	0
Anthoxanthum odoratum	3.0	2.0	1.5	1.0	2.0	2.5	0.5	2.5
Arrhenatherum elatius	0	0	0	0	0	0	2.0	0.5
Cynosurus cristatus	1.0	0.5	1.0	1.5	3.5	2.5	5.0	1.5
Dactylis glomerata	0	0.5	1.5	0	0.5	1.5	2.5	2.0
Deschampsia cespitosa	1.5	0	0	0.5	0	0	0	0
Festuca rubra	3.0	4.5	2.5	5.5	13.0	8.5	10.5	9.5
Holcus lanatus	3.5	4.0	4.5	3.5	11.0	7.5	2.0	5.0
Lolium perenne	15.0	17.5	17.5	19.0	21.5	16.0	18.5	22.0
Phleum pratense	1.5	3.5	3.5	3.5	1.5	2.0	2.5	3.5
Poa spp.	3.5	3.0	2.0	2.0	0.5	0.5	2.0	2.5
Rushes	0.5	0	0.5	0.5	0	0	0	0
Grasses and rushes	38.0	43.0	42.5	49.5	58.0	43.5	48.5	52.0
Achillea millefolium	0	0	0.5	0.5	0	0	0	0
Bellis perennis	0	0	0.5	0	0	0	0	0
Cirsium vulgare	2.5	2.5	3.0	6.0	2.0	0	0	0.5
Galium aperinae	1.5	0	0.5	1.0	0	0	0	0
Leontodon autumnalis	0.5	0	0	0	0	0	0	0.5
Plantago lanceolata	0.5	0	0.5	0	1.0	0	0	0
Prunella vulgaris	0.5	0	0	0	0	0	0	0
Ranunculus spp.	0	1.0	0.5	2.0	7.0	4.5	0	2.5
Rumex spp.	0.5	0.5	1.5	0	0	0	0.5	0
Taraxacum officinale	0.5	2.5	0	0.5	1.0	1.5	0	2.5
Trifolium repens	0	0	0.5	0.5	1.0	0.5	0	0
Urtica dioica	0	0	0	0	0	0	0	0
Other forbs	0	0	2.5	0	0	0	0	0
Total forbs	6.5	6.5	10.0	10.5	12.0	6.5	0.5	5.5
Rubus spp.	0	0	0	0	0	0.5	0	0
Broad leaved trees	30.0	24.5	27.0	23.0	20.0	31.5	37.5	33.5
Taxus baccata	2.0	1.5	0.5	3.0	6.0	9.5	12.0	7.5
Mast	22.5	21.5	20.5	12.0	3.0	8.0	0	1.0
Moss	1.0	3.0	0.5	2.0	1.0	0.5	1.5	0.5
Date when shot	27/10/82		27/10/82		9/ 9/83		9/ 9/83	

Appendix 5.1 (continued) **Botanical composition,percent,of the diets of culled fallow bucks. Comparison of rumenal contents and rectal faecal pellet analysis.**

Buck number	5		6		7		8	
Plant species	Rum	Rec	Rum	Rec	Rum	Rec	Rum	Rec
Agrostis spp.	3.0	3.0	4.0	5.5	4.0	5.0	4.5	3.5
Alopecurus pratensis	0	0	0	0	0	0.5	0	0
Anthoxanthum odoratum	1.0	2.0	3.0	3.0	1.0	1.5	4.0	4.5
Arrhenatherum elatius	1.0	2.0	0.5	1.0	1.5	1.5	0.5	0.5
Cynosurus cristatus	4.0	3.5	4.0	2.5	6.0	4.0	3.0	3.0
Dactylis glomerata	0	0.5	3.0	1.0	1.5	2.5	0.5	1.0
Deschampsia cespitosa	0	0	0.5	0	0.5	0	0	0
Festuca rubra	8.0	6.5	11.0	13.0	10.5	7.5	12.0	8.0
Holcus lanatus	6.0	5.0	4.0	7.0	4.0	9.0	5.0	6.0
Lolium perenne	17.5	17.0	19.0	23.5	17.0	17.5	18.5	21.0
Phleum pratense	3.5	2.0	3.5	4.0	0.5	3.5	4.0	1.5
Poa spp.	1.5	1.5	2.0	2.5	0.5	3.0	1.0	2.0
Rushes	0	0	0	0	0	0	0	0
Grasses and rushes	45.5	43.0	54.5	63.0	47.0	55.5	53.0	51.0
Achillea millefolium	0	0	0	0	0	0	0	0
Bellis perennis	0	0	0.5	0.5	0	0	0	0
Cirsium vulgare	0	0.5	7.0	2.5	0	0	0	1.5
Galium aperinae	1.5	0	0.5	0	0.5	0	0	0.5
Leontodon autumnalis	0	0.5	1.0	0	0	0	1.5	0.5
Plantago lanceolata	1.0	1.0	0	0	1.0	0.5	0.5	0
Prunella vulgaris	0.5	0	0.5	0	0	0	0	0
Ranunculus spp.	5.0	11.5	0	0.5	5.0	9.0	2.0	5.5
Rumex spp.	1.5	0	0	1.0	0.5	0	0	0
Taraxacum officinale	1.5	2.0	1.0	0	2.0	2.0	2.0	2.0
Trifolium repens	0	0	0.5	0.5	0.5	0.5	0	0
Urtica dioica	0	0	0	0	0.5	0	0.5	0
Other forbs	0	0	0	0	0	0	1.0	0
Total forbs	11.0	15.5	11.0	5.0	10.0	12.0	7.5	10.0
Rubus spp.	0.5	0	0	0	0	0.5	0	0
Broad leaved trees	33.5	32.5	27.5	25.5	30.0	24.0	28.5	26.5
Taxus baccata	2.0	3.0	4.5	5.5	10.5	3.5	10.5	10.5
Mast	7.0	5.0	0	0	0.5	2.5	0	0.5
Moss	0.5	1.0	2.5	1.0	2.0	2.5	0.5	1.5
Date when shot	9/ 9/83		9/ 9/83		9/ 9/83		9/ 9/83	

Appendix 5.1 (continued) Botanical composition, percent, of the diets of culled fallow bucks.
Comparison of rumenal contents and rectal faecal pellet analysis.

Buck number	9		10		11		12	
Plant species	Rum	Rec	Rum	Rec	Rum	Rec	Rum	Rec
Agrostis spp.	6.5	4.5	5.5	9.5	2.5	3.0	5.5	6.0
Alopecurus pratensis	0	0.5	1.0	0.5	0	0	0	1.0
Anthoxanthum odoratum	2.5	1.5	2.0	2.0	0.5	0	0	1.0
Arrhenatherum elatius	0	0.5	1.0	0.5	0	1.5	0	0.5
Cynosurus cristatus	4.0	4.5	4.5	5.0	6.5	4.0	5.0	4.0
Dactylis glomerata	2.5	0.5	2.5	1.5	0.5	1.5	1.5	1.0
Deschampsia cespitosa	0.5	0	0.5	0.5	1.0	1.0	0.5	0
Festuca rubra	11.5	13.5	9.5	14.0	6.5	8.0	10.5	12.0
Holcus lanatus	4.0	7.0	6.5	4.0	5.5	5.0	5.5	2.5
Lolium perenne	19.0	18.5	22.0	19.5	17.5	14.5	20.5	21.0
Phleum pratense	3.0	4.0	1.5	5.0	0.5	2.5	0.5	3.5
Poa spp.	1.5	2.0	1.0	2.0	2.5	0.5	1.0	2.0
Rushes	1.5	0	0.5	0.5	0.5	0	0	0
Grasses and rushes	56.5	57.0	58.0	64.5	44.0	41.5	50.5	54.5
Achillea millefolium	0	0.5	0	0	0	0	0	0
Bellis perennis	0	0	0	2.5	0	0	0	0
Cirsium vulgare	0	1.5	0	0	2.5	4.5	1.0	2.0
Galium aperinae	0	0	0	0	0.5	0	0	0.5
Leontodon autumnalis	0.5	1.0	0.5	0	0	1.0	1.5	0.5
Plantago lanceolata	1.5	1.0	0	0	0.5	0	0	0.5
Prunella vulgaris	0	0	0	0	2.0	0	0.5	0.5
Ranunculus spp.	4.0	4.5	2.5	1.0	4.5	7.0	1.5	5.0
Rumex spp.	0	1.0	0.5	0	0.5	0.5	0.5	0.5
Taraxacum officinale	1.5	1.0	1.0	1.5	2.0	1.0	1.5	2.5
Trifolium repens	0	0.5	0	0	0	0	1.5	0
Urtica dioica	0	0	0	0	0.5	0	0	0.5
Other forbs	0	0	0	0.5	0	2.0	0	0.5
Total forbs	7.5	11.0	4.5	5.5	13.5	16.0	8.0	13.5
Rubus spp.	0	0	0	0	0	0	0	0
Broad leaved trees	25.0	23.0	28.0	26.0	26.0	21.5	29.5	22.0
Taxus baccata	7.0	4.0	9.5	2.0	9.0	10.0	10.5	7.5
Mast	0.5	3.0	0	0	1.0	1.0	0.5	0.5
Moss	2.5	2.0	0	2.0	5.5	10.0	1.0	2.0
Date when shot	9/ 9/83		9/ 9/83		30/ 9/83		30/ 9/83	

Appendix 5.2 Botanical composition, percent, of the diets of culled fallow does.
Comparison of rumenal contents and rectal faecal pellet analysis.

Doe number	1		2		3		4	
Plant species	Rum	Rec	Rum	Rec	Rum	Rec	Rum	Rec
Agrostis spp.	4.5	6.0	3.5	5.5	5.0	5.5	3.5	7.0
Alopecurus pratensis	0	0.5	0	0.5	0	0	0.5	0
Anthoxanthum odoratum	0	0	0.5	0.5	1.5	0.5	1.0	2
Arrhenatherum elatius	0.5	0.5	0	0	0	0	0.5	0.5
Cynosurus cristatus	7.5	7.5	2.5	3.0	8.0	5.5	7.0	8.0
Dactylis glomerata	1.5	0.5	1.5	0.5	1.5	2.0	2.5	1.0
Deschampsia cespitosa	0.5	0	0.5	1.0	0	0.5	1.5	0
Festuca rubra	7.0	5.5	3.5	4.5	8.0	3.0	6.0	4.0
Holcus lanatus	3.5	0	2.5	0.5	1.5	2.0	3.5	1.5
Lolium perenne	18.0	17.0	17.5	20.0	20.0	15.0	18.5	19.5
Phleum pratense	0.5	0	0.5	1.0	0.5	0	0.5	0.5
Poa spp.	0.5	2.5	1.0	1.0	2.0	2.0	1.5	2.5
Rushes	1.5	1.0	0.5	0.5	1.0	0	0.5	1.0
Grasses and rushes	45.4	41.0	34.5	38.5	49.0	36.0	47.0	45.5
Achillea millefolium	0.5	0.5	1.0	0.5	0.5	0.5	0.5	1.0
Bellis perennis	0	1.5	0.5	0.5	0	0	1.0	0
Cirsium vulgare	0.5	0.5	8.5	8.0	9.5	10.0	19.5	14.0
Galium aperinae	2.0	1.5	0	2.0	1.5	0.5	1.0	0.5
Leontodon autumnalis	2.0	1.0	0	1.0	0.5	1.0	0.5	2.0
Plantago lanceolata	2.0	2.0	1.0	0.5	0	0.5	0	0
Prunella vulgaris	0	1.5	0.5	0.5	0	0.5	0	0
Ranunculus spp.	3.0	5.5	1.0	5.0	0	3.5	0	3.0
Rumex spp.	0.5	0	1.5	2.0	1.0	1.0	1.5	1.5
Taraxacum officinale	1.0	0.5	0.5	2.0	2.5	3.5	2.5	5.0
Trifolium repens	1.5	1.5	3.5	5.0	0.5	3.0	3.0	3.0
Urtica dioica	2.0	7.5	0.5	3.5	0.5	1.5	0	5.5
Other forbs	2.0	3.5	1.5	2.0	0.5	0.5	0	0
Total forbs	17.0	27.0	20.0	32.5	17.0	26.0	29.5	35.5
Rubus spp.	1.0	4.5	0	0	0	0	0	0
Broad leaved trees	11.0	11.0	14.5	15.0	18.0	16.0	12.5	7.5
Taxus baccata	2.5	1.0	3.5	4.0	1.0	5.5	2.5	3.5
Mast	17.0	10.0	24.5	9.0	12.5	12.5	6.5	3.0
Moss	6.0	5.5	3.0	1.0	2.5	3.5	2.0	5.0
Date when shot	17/11/82		17/11/82		17/11/82		17/11/82	

Appendix 5.2 (continued) **Botanical composition, percent, of the diets of culled does. Comparison of rumenal contents and rectal faecal pellet analysis.**

Doe number	5		6		7		8	
Plant species	Rum	Rec	Rum	Rec	Rum	Rec	Rum	Rec
Agrostis spp.	4.0	5.0	6.0	7.0	8.0	6.0	10.5	9.0
Alopecurus pratensis	1.0	0.5	0	0	0	0	1.0	3.5
Anthoxanthum odoratum	1.5	1.0	0.5	0.5	1.0	0.5	2.5	2.0
Arrhenatherum elatius	0.5	1.0	0	0	0	0	0	4.5
Cynosurus cristatus	7.0	6.5	6.5	4.0	10.0	5.0	7.0	3.5
Dactylis glomerata	2.0	4.0	2.5	1.5	0.5	0.5	3.5	1.0
Deschampsia cespitosa	0.5	0	0	0	0	0	0	0
Festuca rubra	5.5	5.0	8.0	9.5	12.5	8.5	12.0	6.5
Holcus lanatus	5.0	3.5	5.0	3.0	3.5	2.0	2.0	2.5
Lolium perenne	18.0	17.0	24.0	26.0	32.5	33.0	31.0	32.0
Phleum pratense	0.5	0.5	1.0	0.5	0.5	0	1.0	0.5
Poa spp.	1.0	1.5	1.0	1.0	1.5	2.0	6.5	5.0
Rushes	0.5	0.5	1.5	1.5	0	0.5	0.5	0.5
Grasses and rushes	47.0	46.0	56.0	54.5	70.0	58.0	77.5	70.5
Achillea millefolium	0.5	0.5	0.5	0	0.5	0	0	0
Bellis perennis	0	0.5	0	0	0	0	0	0
Cirsium vulgare	3.0	4.0	5.0	4.0	0.5	1.0	3.5	4.0
Galium aperinae	0	0	1.0	1.0	0	0.5	0.5	0.5
Leontodon autumnalis	5.0	2.5	1.5	1.0	0	0.5	0	0
Plantago lanceolata	0.5	0	0	0	0	0	0.5	0.5
Prunella vulgaris	0	0	0.5	0	0	0	0	0
Ranunculus spp.	0	4.0	1.5	6.5	4.5	3.5	1.0	8.5
Rumex spp.	0.5	0	0	0	0	0.5	0.5	0
Taraxacum officinale	2.5	3.5	1.5	2.5	0	1.5	0	0.5
Trifolium repens	1.0	2.5	2.5	1.0	3.0	1.5	2.5	1.0
Urtica dioica	1.0	3.0	0	0	0	0.5	0	0
Other forbs	0.5	1.5	1.5	1.5	0	0	0	0
Total forbs	14.5	22.0	15.5	17.5	8.5	9.5	8.5	15.0
Rubus spp.	0	0.5	0	0	0	0	0	0
Broad leaved trees	14.5	10.0	9.0	7.0	11.5	13.0	7.5	4.5
Taxus baccata	2.5	3.0	4.5	4.0	0	2.0	3.0	5.0
Mast	11.0	10.0	0	0.5	0.5	2.0	0	0.5
Moss	10.5	8.5	15.0	16.0	9.5	15.5	3.5	4.5
Date when shot	17/11/82		6/12/82		6/12/82		13/12/82	

Appendix 5.2 (continued) Botanical composition, percent, of the diets of culled fallow does. Comparison of rumenal contents and rectal faecal pellet analysis.

Doe number	9		10		11		12	
Plant species	Rum	Rec	Rum	Rec	Rum	Rec	Rum	Rec
Agrostis spp.	6.0	3.0	0.5	3.5	8.0	8.5	5.5	6.5
Alopecurus pratensis	0	0	0	0	1.5	1.5	1.0	0
Anthoxanthum odoratum	0.5	2.0	0	0	0.5	0	3.5	4.5
Arrhenatherum elatius	0	1.0	1.0	0.5	0	1.5	1.0	2.5
Cynosurus cristatus	3.5	0	0.5	1.5	10.5	4.5	11.5	4.5
Dactylis glomerata	2.0	1.0	0.5	1.0	1.0	2.5	0	0
Deschampsia cespitosa	0	0.5	0	0	0	0	0	0
Festuca rubra	10.0	5.5	1.5	2.5	7.0	5.5	10.0	7.0
Holcus lanatus	4.5	1.0	5.5	10.5	4.0	5.5	10.5	7.5
Lolium perenne	24.5	19.0	10.0	14.0	33.5	24.5	24.5	25.5
Phleum pratense	0	0.5	1.0	0	2.0	1.5	2.5	9.0
Poa spp.	1.0	0.5	0.5	0.5	2.5	5.0	1.0	1.5
Rushes	0	1.0	20.5	1.0	0.5	0	1.0	0
Grasses and rushes	52.0	35.0	41.5	35.0	71.0	60.5	72.0	68.5
Achillea millefolium	0	0	0	0	0	0.5	0	0
Bellis perennis	0	0	1.0	1.0	0	0	0	0
Cirsium vulgare	1.0	1.0	2.0	3.5	0	1.0	0	0.5
Galium aperinae	0	0	1.5	0	0	0.5	0	0
Leontodon autumnalis	0	0	0	0	0	0	0	0.5
Plantago lanceolata	0	0	0	0	0	0	0	0
Prunella vulgaris	0	0	0	0	0	0	0	0
Ranunculus spp.	1.5	2.5	9.0	13.0	2.5	3.5	4.5	7.0
Rumex spp.	0.5	1.0	0	0	0	0	0	0
Taraxacum officinale	0	0.5	0.5	3.5	0	0	0	1.0
Trifolium repens	0	0	1.0	0	1.0	0.5	0	0
Urtica dioica	1.0	1.5	0	0	0	0	0	0
Other forbs	3.0	0	1.0	2.5	0.5	0	1.0	0
Total forbs	7.0	6.5	16.0	23.5	4.0	6.0	5.5	9.0
Rubus spp.	26.5	31.0	8.5	16.0	0.5	2.0	0	1.0
Broad leaved trees	8.5	12.0	9.0	15.0	9.0	8.0	8.0	9.5
Taxus baccata	0	12.5	21.5	8.5	4.0	12.0	7.5	5.0
Mast	0	1.0	3.0	1.5	1.0	2.0	1.0	0.5
Moss	6.0	2.0	0.5	0.5	10.5	9.5	6.0	6.5
Date when shot	21/12/82		21/12/82		21/12/82		21/12/82	

Appendix 5.3 Overall average*of plant species/groups, percent consumed by the herbivores

Plant species/group	Bucks*	Does*	Cattle	Sheep
Agrostis spp.	6.3	5.0	7.0	4.4
Alopecurus pratensis	0.3	0.4	2.6	1.2
Anthoxanthum odoratum	1.0	0.6	2.2	2.6
Arrhenatherum elatius	0.7	1.9	2.0	2.0
Cynosurus cristatus	4.5	3.7	4.7	4.7
Dactylis glomerata	2.6	2.3	1.9	2.2
Deschampsia cespćtosa	2.6	0.7	0.8	0.7
Festuca rubra	12.9	10.2	8.5	15.8
Holcus lanatus	1.5	1.9	7.6	1.9
Lolium perenne	14.5	15.3	16.5	21.4
Phleum pratense	1.8	3.0	3.8	2.0
Poa spp.	1.0	1.2	2.3	1.6
Rushes	0.5	0.5	0.6	0.5
Total grasses	50.2	47.2	60.5	61.0
Cirsium vulgare	0.8	1.3	0.2	0.2
Prunella vulgare	2.0	1.9	1.9	1.9
Ranunculus spp.	5.4	6.6	4.5	5.6
Taraxacum officinale	2.4	2.4	3.3	3.5
Trifolium repens	2.1	1.5	0.4	2.5
Urtica dioica	1.2	1.6	0.4	0.3
Other species	1.4	3.0	3.2	3.0
Total forbs	15.3	18.3	13.9	17.0
Rubus spp.	4.9	0.5	0.0	0.0
Broad leaved trees	9.5	10.1	9.2	6.4
Taxus baccata	8.2	10.3	2.4	1.0
Mast	2.2	4.5	0.1	0
Moss	9.6	9.7	14.0	14.6

* Calculated for all the months deer wwere on the range.

P.S. Totals do not add up to 100 because of rounding off.

APPENDIX 5.3.1 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF TOTAL GRASSES IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	59.3 (2.0)	48.0 (5.5)	25.6 (0.4)	44.9 (4.1)	42.1 (0.7)	38.3 (2.2)	48.1 (3.9)	48.4 (1.8)	52.0 (3.4)	50.8 (2.2)	63.7 (4.1)	68.4 (3.6)	57.9 (4.0)	58.8 (2.4)	45.9 (2.0)	52.3
FALLOW DOES	50.5 (6.2)	24.0 (3.9)	37.5 (3.5)	49.5 (3.1)	53.9 (3.3)	36.0 (2.7)	34.0 (4.5)	51.5 (3.9)	40.7 (4.1)	32.4 (0.9)	46.8 (4.7)	60.1 (4.1)	67.4 (2.0)	65.2 (2.6)	57.8 (3.0)	47.5
CATTLE	---	63.4 (3.2)	53.0 (3.1)	---	---	---	---	---	43.5 (1.4)	53.5 (4.6)	81.0 (1.9)	84.2 (2.3)	76.0 (0.8)	47.0 (0.6)	42.9 (2.6)	60.6
SHEEP	61.2 (2.0)	63.4 (2.6)	---	---	---	---	---	44.8 (5.7)	45.0 (2.1)	55.0 (2.6)	82.8 (1.9)	69.2 (3.6)	67.0 (4.2)	---	---	61.0

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES		B**	D*		D*		B*			B***	B**		D*	D*		
BUCKS vs CATTLE	---	C*	C***	---	---	---	---	---			C**	C**		B**		
BUCKS vs SHEEP		S*	---	---	---	---	---				S**			---	---	
DOES vs CATTLE	---	C***	C*	---	---	---	---	---		C***	C**	C**	C**	D***		
DOES vs SHEEP		S***	---	---	---	---	---			S***	S**			---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---				C**	C**	---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.2 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Lolium perenne* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	15.8 (1.4)	15.1 (1.2)	8.8 (0.8)	16.7 (0.9)	12.6 (1.1)	13.5 (0.5)	15.6 (2.9)	12.9 (1.6)	11.9 (1.2)	11.0 (0.7)	14.3 (1.8)	20.8 (1.7)	16.6 (1.1)	20.4 (1.5)	10.9 (0.6)	14.4
FALLOW DOES	19.0 (3.1)	9.0 (1.3)	16.0 (1.8)	20.0 (1.6)	25.2 (2.3)	13.5 (0.5)	12.5 (2.9)	17.0 (2.6)	13.9 (1.5)	9.9 (1.0)	13.4 (2.2)	18.8 (1.8)	16.3 (1.8)	13.6 (1.6)	11.2 (0.7)	14.4
CATTLE	---	18.3 (1.6)	12.5 (1.9)	---	---	---	---	---	17.0 (1.3)	14.5 (0.5)	18.0 (1.7)	21.3 (2.1)	17.0 (2.1)	14.5 (1.7)	15.1 (1.8)	16.5
SHEEP	22.2 (1.8)	22.5 (2.1)	---	---	---	---	---	17.1 (2.6)	19.0 (3.7)	20.6 (2.8)	25.8 (0.3)	23.4 (1.9)	20.8 (1.5)	---	---	21.4

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES		B*	D*		D***								B*			
BUCKS vs CATTLE	---			---	---	---	---						B*			
BUCKS vs SHEEP		S**	---	---	---	---	---			S**	S***		---	---		
DOES vs CATTLE	---	C**		---	---	---	---	---								
DOES vs SHEEP		S***	---	---	---	---	---			S***	S***		---	---		
CATTLE vs SHEEP	---	S*	---	---	---	---	---			S*	S***		---	---		

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.3 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Festuca rubra* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	11.8 (1.9)	14.2 (2.4)	6.0 (0.8)	12.0 (1.9)	11.2 (0.8)	14.4 (1.5)	15.2 (1.1)	17.1 (1.1)	8.4 (0.6)	9.1 (1.7)	13.4 (1.0)	15.4 (1.9)	17.4 (2.4)	13.0 (3.0)	14.5 (1.8)	12.8
FALLOW DOES	12.5 (1.5)	7.0 (1.0)	10.5 (0.8)	11.5 (1.5)	15.1 (2.4)	9.5 (1.0)	8.5 (1.3)	11.0 (2.1)	4.1 (0.8)	5.0 (1.4)	9.5 (1.8)	13.5 (0.9)	14.0 (1.3)	11.7 (1.4)	8.9 (0.9)	9.8
CATTLE	---	9.4 (1.5)	7.5 (0.8)	---	---	---	---	---	6.5 (1.0)	6.5 (1.0)	13.0 (1.3)	9.9 (1.5)	10.0 (1.4)	7.5 (1.0)	5.9 (1.5)	8.5
SHEEP	15.1 (1.9)	17.7 (1.3)	---	---	---	---	---	9.5 (2.9)	11.0 (1.3)	17.7 (1.9)	21.1 (1.2)	16.8 (1.9)	17.2 (1.0)	---	---	15.8

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES		B**	D**			B*	B**		B**							B*
BUCKS vs CATTLE	---			---	---	---	---	---				B*	B**			B**
BUCKS vs SHEEP			---	---	---	---	---			S**	S**			---		---
DOES vs CATTLE	---			---	---	---	---	---								
DOES vs SHEEP		S**	---	---	---	---	---		S***	S***	S***			---		---
CATTLE vs SHEEP	---	S**	---	---	---	---	---	---	S**	S***	S**	S*	S**	---		---

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.4 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Agrostis* spp. IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	9.5 (1.5)	5.0 (1.4)	4.7 (0.6)	6.0 (2.4)	6.1 (0.9)	3.6 (1.3)	5.6 (1.5)	4.6 (0.5)	10.1 (0.9)	7.2 (2.0)	6.5 (2.4)	7.2 (1.3)	7.2 (0.7)	5.6 (0.8)	5.5 (1.8)	7.2
FALLOW DOES	6.5 (2.2)	2.0 (1.4)	5.5 (1.7)	6.5 (1.3)	4.4 (0.9)	5.5 (1.0)	5.0 (1.7)	6.0 (0.8)	4.1 (1.9)	2.3 (0.5)	4.8 (0.8)	4.9 (0.5)	7.1 (2.4)	6.2 (1.2)	4.5 (1.0)	4.9
CATTLE	---	9.4 (1.5)	5.5 (1.0)	---	---	---	---	---	3.5 (1.5)	6.0 (1.2)	5.0 (1.3)	10.8 (0.7)	11.5 (1.0)	7.0 (0.5)	4.4 (1.2)	7.0
SHEEP	6.6 (2.0)	3.4 (1.9)	---	---	---	---	---	4.8 (0.9)	3.0 (0.6)	1.4 (0.5)	6.2 (0.9	5.6 (0.6)	6.3 (1.7)	---	---	4.4

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES									B**	B**						
BUCKS vs CATTLE	---			---	---	---	---	---	B**			C*				
BUCKS vs SHEEP			---	---	---	---	---		B**	B**				---	---	
DOES vs CATTLE	---	C**		---	---	---	---	---		C*		C***				
DOES vs SHEEP			---	---	---	---	---							---	---	
CATTLE vs SHEEP	---	C*	---	---	---	---	---	---		C*		C***		---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.5 : MEAN PERCENTAGE ± SE. (IN BRACKETS) OF *Cynosurus cristatus* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	5.4 (1.1)	3.7 (0.7)	0.9 (1.0)	3.2 (0.8)	5.1 (0.5)	3.2 (1.4)	4.3 (0.6)	6.5 (0.5)	5.7 (1.0)	3.4 (0.6)	4.8 (0.7)	4.5 (0.9)	4.3 (0.6)	4.2 (1.4)	7.7 (1.2)	4.7
FALLOW DOES	2.0 (0.8)	2.5 (0.5)	3.0 (1.0)	2.0 (0.0)	2.9 (1.2)	3.0 (0.6)	2.5 (1.3)	4.0 (1.4)	4.6 (1.1)	3.2 (0.5)	4.3 (0.9)	4.5 (0.9)	4.8 (0.9)	5.8 (1.5)	6.7 (0.8)	4.1
CATTLE	---	3.5 (0.5)	3.5 (1.0)	---	---	---	---	---	2.5 (0.5)	3.5 (1.5)	7.5 (1.0)	7.4 (0.5)	6.0 (0.8)	3.5 (1.0)	4.9 (0.6)	4.7
SHEEP	4.2 (1.3)	5.2 (1.8)	---	---	---	---	---	2.9 (0.6)	3.0 (1.0)	3.8 (1.1)	7.2 (0.7)	3.3 (0.5)	5.4 (0.8)	---	---	4.7

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES																
BUCKS vs CATTLE	---			---	---	---	---	---			C*	C*				
BUCKS vs SHEEP			---	---	---	---	---	---						---	---	
DOES vs CATTLE	---			---	---	---	---	---			C*	C*				
DOES vs SHEEP			---	---	---	---	---	---			S*			---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---				C**		---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.6 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Holcus lanatus* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0.9 (0.5)	2.3 (0.5)	0.0	0.5 (0.4)	0.9 (0.4)	0.0	0.0	1.8 (1.1)	0.4 (0.5)	1.0 (1.0)	9.1 (2.2)	3.6 (1.7)	1.7 (1.3)	0.0	0.0	1.9
FALLOW DOES	1.5 (0.5	1.5 (1.0)	0.0	3.5 (0.5)	0.0	0.5 (0.5)	2.0 (1.4)	2.5 (1.0)	2.1 (0.9)	0.5 (0.4)	1.7 (0.7)	1.4 (0.8)	0.9 (0.9)	10.1 (2.4)	0.5 (0.4)	1.9
CATTLE	---	6.9 (2.3)	8.0 (0.8)	---	---	---	---	---	3.0 (0.6)	3.0 (1.0)	10.5 (1.5)	11.8 (1.9)	14.0 (2.2)	5.0 (1.3)	2.9 (1.8)	7.6
SHEEP	3.8 (1.9)	2.4 (0.5)	---	---	---	---	---	1.0 (1.0)	1.5 (0.5)	0.5 (0.5)	1.4 (0.5)	3.3 (1.9)	1.4 (0.9)	---	---	1.9

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES				D**							B**			D**		
BUCKS vs CATTLE	---	C*		---	---	---	---	---		C*		C**	C***			
BUCKS vs SHEEP			---	---	---	---	---				B**			---	---	
DOES vs CATTLE	---	C*		---	---	---	---	---		C*	C***	C***	C***			
DOES vs SHEEP			---	---	---	---	---							---	---	
CATTLE vs SHEEP	---	C*	---	---	---	---	---	---		C*	C***	C**	C***	---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.7 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Dactylis glomerata* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	1.4 (0.5)	1.8 (0.7)	0.0	2.3 (0.6)	1.4 (0.5)	1.8 (0.7)	1.7	2.8 (0.9)	4.9 (0.4)	5.7 (0.9)	3.0 (0.8)	4.5 (0.6)	3.8 (0.7)	3.2 (0.5)	1.4 (0.9)	3.0
FALLOW DOES	0.5 (0.5)	1.5 (1.0)	1.0 (1.2)	1.0 (0.5)	1.5 (0.9)	0.5 (0.5)	0.0	5.0 (1.0)	1.0 (0.6)	2.7 (0.5)	4.3 (0.9)	3.6 (1.3)	2.6 (1.2)	3.9 (0.5)	4.9 (1.2)	2.8
CATTLE	---	3.0 (1.0)	1.5 (0.5)	---	---	---	---	---	1.0 (0.6)	2.0 (0.8)	4.5 (1.0)	1.5 (0,9)	1.5 (1.0)	2.0 (1.2)	0.5 (0,5)	1.9
SHEEP	0.9 (0.5)	1.0 (0.0)	---	---	---	---	---	0.5 (0.5)	2.0 (0.0)	2.9 (1.7)	3.8 (0,1)	2.3 (1.0)	4.1 (0.9)	---	---	2.2

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES									B***						D*	
BUCKS vs CATTLE	---			---	---	---	---	---	B***							
BUCKS vs SHEEP			---	---	---	---	---		B**					---	---	
DOES vs CATTLE	---			---	---	---	---	---							D**	
DOES vs SHEEP			---	---	---	---	---	D**						---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---						---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.8 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Phleum pratense* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	2.7 (0.8)	0.9 (0.5)	1.4 (0.9)	2.3 (0.9)	2.8 (1.2)	0.9	0.9	0.0	1.8 (0.7)	2.9 (1.3)	4.5 (0.8)	2.7 (1.2)	0.9 (1,2)	0,9 (0.5)	0,9 (0.9)	1.8
FALLOW DOES	2.5 (1.3)	0.5 (0.5)	1.0 (0.6)	2.0 (0.8)	1.9 (0.8)	2.0 (1.16)	1.0 (.58)	3.5 (.96)	2.1 (0.8)	0.9 (0.9)	0.4 (0,5)	3,1 (1.5)	10,1 (1,1)	7,0 (0,5)	7,1 (1,3)	3.5
CATTLE	---	5.0 (1.9)	3.5 (1.0)	---	---	---	---	---	1,5 (1.0)	6,5 (1.5)	7.0 (1,3)	3,5 (1.7)	5.0 (1.7)	1,5 (1,0)	0,5 (0.5)	3.8
SHEEP	1.9 (1.2)	1.0 (0.5)	---	---	---	---	---	0.5	0.5 (0.0)	2,4 (0.9)	2,9 (0,6)	2,8 (1.2)	3,6 (1.5)	---	---	2,0

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES											B**		D**	D***	D***	
BUCKS vs CATTLE	---	C*		---	---	---	---	---								
BUCKS vs SHEEP			---	---	---		---							---	---	
DOES vs CATTLE	---	C*		---	---		---	---		C**	C***		D*	D***	D***	
DOES vs SHEEP			---	---	---		---						D**	---	---	
CATTLE vs SHEEP	---	C*	---	---	---		---	---		C*	C**			---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.9 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Deschampsia cespitosa* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	5.0 (1.6)	0.9 (0.5)	1.4 (0.9)	0.5	0	0.5	1.7 (.03)	1.4	4.4 (1.0)	4.3 (1.5)	2.6 (0.8)	0.9 (0.5)	1.3 (0.8)	10.7 (1.18)	3.6 (1.18)	3.3
FALLOW DOES	0	0	0	0	0	0	0	0.5	3.6 (0.6)	2.7 (2.0)	0	1.3 (0.8)	0.9 (0.5)	0.4	0.5	0.9
CATTLE	---	0	1.0 (0.6)	---	---	---	---	---	1.0 (1.0)	0.5 (0.5)	2.0 (1.2)	1.5 (0.5)	1.5 (1.0)	0.0	0	0.8
SHEEP	0.9 (0.9)	1.4 (1.0)	---	---	---	---	---	0	0.5 (0.5)	0	1.9 (1.1)	0	0.5 (0.5)	---	---	0.7

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES	B*										B*		*			
BUCKS vs CATTLE	---			---	---	---	---	---	B*							
BUCKS vs SHEEP	B*		---	---	---	---	---		B**	B*					---	---
DOES vs CATTLE	---			---	---	---	---	---	D*							
DOES vs SHEEP			---	---	---	---	---		D*						---	---
CATTLE vs SHEEP	---		---	---	---	---	---	---				C*			---	---

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - ; Cattle/Sheep not present on the range
No Symbol ; Non-significant

APPENDIX 5.3.10: MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Poa* spp. IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	2.3 (1.1)	0.9 (0.52)	0	0.9 (.53)	0.9 (.56)	0.5	0	0	1.8 (.74)	0	1.3 (.80)	3.6 (1.31)	2.1 (.31)	0	0.5 (.48)	1.1
FALLOW DOES	1.0 (.58)	0	0	0	1.5 (.50)	0.0	1.0 (.58)	1.0 (.58)	1.6 (.53)	0.9 (.52)	2.2 (.41)	1.8 (1.30)	3.5 (1.17)	1.6 (.03)	1.8 (1.04)	1.4
CATTLE	---	1.5 (1.48)	1.5 (.58)	---	---	---	---	---	0.5	1.5 (.96)	1.5 (.96)	7.4 (.95)	2.5 (1.26)	1.5 (.96)	2.4 (.52)	2.3
SHEEP	0.9 (.54)	1.4 (1.00)	---	---	---	---	---	1.0 (.56)	0.5	1.4 (.91)	2.4 (.41)	2.4 (1.25)	2.7 (1.18)	---	---	1.6

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES																
BUCKS vs CATTLE	---			---	---	---	---	---			C*			C**		
BUCKS vs SHEEP		---		---	---	---	---	---						---	---	
DOES vs CATTLE	---			---	---	---	---	---			C**					
DOES vs SHEEP		---		---	---	---	---	---						---	---	
CATTLE vs SHEEP	---	---		---	---	---	---	---			C**			---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.10a: MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Alopecurus pratensis* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0.9 (0.5)	0.5	1.9 (1.3)	0	0.5	0	0	0	0	0	0.9	0.5	0	0	0	
FALLOW DOES	0.5	0	0	1.0 (0.6)	0.5	0	0	0	0	0.5	0.9	0.5	0.9 (0.5)	1.2 (0.7)	0.5	
CATTLE	---	1.8 (0.8)	2.8 (0.6)	---	---	---	---	---	1.0 (0.6)	3.6 (0.8)	4.5 (1.0)	2.5 (1.3)	2.5 (0.5)	1.5 (1.0)	3.4 (1.3)	
SHEEP	0.5	1.0 (0.6)	---	---	---	---	---	1.4 (1.0)	1.0	0.9 (0.6)	2.0 (0.5)	1.4 (0.5)	1.0 (0.6)	---	---	

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)
BUCKS vs DOES	
BUCKS vs CATTLE	
BUCKS vs SHEEP	
DOES vs CATTLE	
DOES vs SHEEP	
CATTLE vs SHEEP	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.10b : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Anthoxonthum odoratum* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	3.2 (0.9)	1.4 (0.5)	0	0	1.0 (0.6)	0	0	0	0.9 (0.5)	1.9 (0.8)	2.6 (0.4)	3.2 (0.5)	0.4	0.5	0	
FALLOW DOES	3.0 (0.6)	0	0.5	1.5 (1.0)	0	0	0	0.5	1.5 (1.0)	0	0	0	0	1.6 (0.6)	0.5	
CATTLE	---	3.0 (1.0)	3.5 (1.5)	---	---	---	---	---	2.0 (0.8)	2.0 (0.8)	1.5 (1.0)	4.5 (1.7)	2.0 (0.8)	1.5 (0.5)	0	
SHEEP	2.4 (0.9)	1.4 (0.5)	---	---	---	---	---	2.9 (0.6)	1.5 (1.0)	2.0 (1.4)	4.3 (0.9)	4.0 (1.3)	2.7 (0.9)	---	---	

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)
BUCKS vs DOES	
BUCKS vs CATTLE	
BUCKS vs SHEEP	
DOES vs CATTLE	
DOES vs SHEEP	
CATTLE vs SHEEP	S *

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.10c : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Arrhenatherum elatius* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0.5	0.9 (0.5)	0.5	0.5	0	0.5	0.5	0.5	1.8 (0,7)	2.4 (1.4)	0.5	0.9 (0,5)	0	0,5	0.9 (0.5)	
FALLOW DOES	0	0	0	0	0	0	0.5	0.5	1.0 (0.6)	4.1 (0.5)	5.2 (1.3)	6.7 (0.8)	7.0 (1,3)	2.7 (1.0)	0.5	
CATTLE	---	1.0 (0.6)	1.0 (0.6)	---	---	---	---	---	2.5 (0.5)	1.0 (0.6)	5.5 (1.7)	2.5 (0.9)	2.5 (1.5)	1.5 (1.0)	0.5	
SHEEP	0	3.5 (1.1)	---	---	---	---	---	3.3 (0,9)	1.5 (1.0)	1.0	3.8 (1.0)	1,4 (0.5)	1.4 (0.9)	---	---	

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES												D ***				
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP		---	---	---	---	---	---								---	
DOES vs CATTLE	---			---	---	---	---	---		D **		D ***	D *			
DOES vs SHEEP			---	---	---	---	---					D ***	D *	---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---						---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.11 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF TOTAL FORBS IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	22.2 (2.1)	9.6 (2.0)	5.6 (2.0)	5.1 (1.8)	4.2 (0.9)	2.7 (1.5)	2.6 (1.2)	30.9 (4.0)	35.7 (2.8)	43.2 (2.1)	25.1 (3.2)	16.7 (3.7)	9.8 (4.0)	6.5 (0.6)	9.6 (3.2)	19.5
FALLOW DOES	16.0 (4.7)	17.0 (2.1)	10.5 (1.9)	12.0 (2.2)	9.3 (1.6)	5.5 (0.5)	12.0 (3.2)	21.0 (3.7)	36.1 (5.0)	20.3 (1.6)	16.5 (3.0)	8.1 (2.4)	20.3 (2.0)	27.8 (3.6)	41.1 (2.4)	22.0
CATTLE	---	16.3 (3.1)	8.0 (3.4)	---	---	---	---	---	32.5 (1.9)	30.0 (2.5)	11.0 (1.3)	7.4 (1.5)	3.3 (0.8)	5.0 (1.7)	11.2 (3.1)	13.7
SHEEP	21.0 (3.0)	13.5 (1.7)	---	---	---	---	---	17.1 (2.9)	27.5 (5.4)	24.9 (2.7)	10.5 (2.3)	14.0 (4.0)	7.8 (4.2)	---	---	17.1

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES							D*			B***	B*		D*	D***	D***	
BUCKS vs CATTLE	---			---	---	---	---	---		B***	B**					
BUCKS vs SHEEP			---	---	---	---	---			B**	B**			---	---	
DOES vs CATTLE	---			---	---	---	---	---		C*			D**	D***	D***	
DOES vs SHEEP			---	---	---	---	---						D*	---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---						---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.12 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Ranunculus* Spp. IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	6.8 (0.4)	1.8 (1.1)	2.3 (0.9)	1.9 (1.1)	1.4 (0.9)	0.5	2.7 (1.2)	10.6 (1.5)	13.2 (1.1)	16.6 (0.6)	7.8 (0.3)	5.0 (1.6)	3.0 (0.4)	3.7 (0.1)	3.6 (1.2)	6.7
FALLOW DOES	5.5 (1.9)	6.5 (1.7)	2.5 (1.3)	6.5 (1.5)	4.0 (1.4)	1.0	2.5 (1.3)	10.0 (2.3)	16.5 (2.7)	4.5 (1.6)	5.6 (0.8)	4.9 (1.7)	7.5 (1.8)	11.0 (0.9)	10.0 (0.8)	7.7
CATTLE	---	9.4 (2.2)	0.5 (0.6)	---	---	---	---	---	10.5 (0.5)	12.0 (1.6)	4.5 (1.7)	1.5 (0.5)	2.0 (0)	0	0	4.5
SHEEP	12.3 (1.6)	4.3 (1.3)	---	---	---	---	---	9.5 (1.7)	9.5 (3.3)	6.2 (1.6)	0	1.9 (0.8)	1.4 (0.5)	---	---	5.6

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES				D*						B***			D**	D***	D***	
BUCKS vs CATTLE	---	C*		---	---	---	---	---		B*	B*			B***	B*	
BUCKS vs SHEEP	S*		---	---	---	---	---			B***	B***			---	---	
DOES vs CATTLE	---			---	---	---	---	---		C**			D**	D***	D***	
DOES vs SHEEP	S**		---	---	---	---	---				D**		D***	---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---		C*	C**			---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.13: MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Prunella vulgaris* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	5.9 (0.4)	2.3 (0.9)	0	1.4	0.9 (.52)	0	0	2.3 (1.4)	3.5 (0.8)	5.3 (2.3)	3.0 (1.0)	1.4 (0.5)	0.9 (0.5)	1.4 (0.5)	1.8 (1.1)	2.5
FALLOW DOES	3.0 (1.0)	1.0 (0.6)	1.0 (.58)	0.5	0	0	1.5 (.96)	0	1.6 (0.5)	0.9 (0.9)	1.7 (0.7)	0.9 (0.5)	3.5 (1.6)	3.5 (2.0)	8.9 (0.3)	2.4
CATTLE	---	2.0 (0.9)	1.5 (.50)	---	---	---	---	---	2.5 (0.5)	3.5 (1.3)	3.0 (1.0)	0	0	4.0 (1.2)	0.5 (0.5)	1.9
SHEEP	2.4 (0.9)	2.9 (0.6)	---	---	---	---	---	1.9 (0.5)	2.5 (1.0)	2.4 (0.9)	0.5 (0.5)	1.9 (1.3)	0.5 (0.5)	---	---	1.9

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES	B*															D***
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP	B*		---	---	---	---	---	---							---	---
DOES vs CATTLE	---			---	---	---	---	---								D***
DOES vs SHEEP			---	---	---	---	---	---							---	---
CATTLE vs SHEEP	---		---	---	---	---	---	---							---	---

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.14 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Taraxacum officinale* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	2.7 (1.2)	0	0	0	0	0	0	12.0 (1.8)	8.4 (1.9)	8.6 (1.6)	1.7 (0.7)	0.5	1.3 (.44)	0	0	3.2
FALLOW DOES	1.5 (1.0)	1.5 (.48)	0.5	1.5 (.50)	0	0	3.5 (2.06)	8.5 (1.5)	11.3 (2.5)	1.4 (0.4)	0	0.5	0	1.2 (.72)	4.5 (1.67)	3.0
CATTLE	---	2.0 (.85)	1.5 (.96)	---	---	---	---	---	10.5 (0.5)	11.0 (3.4)	3.0 (1.0)	0.5	0	0.5	0.5	2.9
SHEEP	2.8 (0.9)	2.9 (.62)	---	---	---	---	---	2.4 (1.4)	10.5 (1.9)	3.8 (0.8)	2.4 (0.9)	1.9 (1.34)	0.9 (.53)	---	---	3.4

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES									B*							
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP			---	---	---	---	---	B**							---	---
DOES vs CATTLE	---			---	---	---	---	---	C**							
DOES vs SHEEP			---	---	---	---	---	D*							---	---
CATTLE vs SHEEP	---		---	---	---	---	---	---	C*						---	---

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.15 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Trifolium repens* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	2.3 (1.4)	3.7 (1.3)	0	0.5	0	0	0	4.2 (1.6)	8.8 (1.9)	5.7 (2.2)	2.6 (0.6)	2.3 (1.2)	1.3 (0.7)	0	0.5 (0.4)	2.9
FALLOW DOES	0	1.0 (1.0)	0	0	0	0	0	0	0.5 (1.0)	10.4 (1.8)	5.2 (2.6)	0.9 (0.9)	0.9 (0.5)	1.2 (0.4)	1.8 (0.7)	2.0
CATTLE	---	1.0 (1.0)	0	---	---	---	---	---	1.5 (1.0)	0.0	0.0	0.5 (0.6)	0.5 (0.5)	0.0	0.5 (0.5)	0.8
SHEEP	1.4 (1.3)	1.0 (0.6)	---	---	---	---	---	0	4.5 (1.3)	5.7 (2.2)	1.9 (0.1)	3.3 (1.2)	2.3 (0.5)	---	---	2.6

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES								B**						D*		
BUCKS vs CATTLE	---			---	---	---	---	---	B**		B*					
BUCKS vs SHEEP			---	---	---	---	---	---	B*						---	---
DOES vs CATTLE	---			---	---	---	---			D**						D*
DOES vs SHEEP			---	---	---	---	---	---							---	---
CATTLE vs SHEEP	---		---	---	---	---	---	---			S***		S***		---	---

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.16: MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Urtica dioica* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	4.1 (1.0)	1.3	0.9	0.5	0	0	0	0	0.4	6.2	1.7 (0.7)	0.9 (0,5)	0	0.9 (0,5)	0.9 (0.5)	1.6
FALLOW DOES	0.5 (0.5)	0	0	0	0	0	0	0	0.5	0.5	1.3 (0.4)	0	0,9	7.4 (1.2)	12,1 (2.4)	2.1
CATTLE	---	0	0.5	---	---	---	---	---	0.5	0	0	1,5 (0,5)	0	0	1.0 (1.0)	0.4
SHEEP	0	1.4	---	---	---	---	---	0	0	0	0	0.5 (0,5)	0.5	---	---	0.3

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES	B*														D***	D**
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP	B*		---	---	---	---	---								---	---
DOES vs CATTLE	---			---	---	---	---	---			D*	C*			D**	D**
DOES vs SHEEP			---	---	---	---	---				D*				---	---
CATTLE vs SHEEP	---		---	---	---	---	---	---							---	---

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.17: MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Cirsium vulgare* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0	0.5	0.9	0.5	0	0	0	0.5	0.9 (.49)	1.4 (.51)	0.9	5.4 (2.58)	0.9	0	0	1.0
FALLOW DOES	0	2.5 (.96)	4.0 (1.41)	2.5 (.50)	0.5	0	0	0	1.6	0.9 (.52)	0	0.5 (.48)	5,3 (.63)	0,4	0,5	1.4
CATTLE	---	0.5	0	---	---	---	---	---	0	0	0	1.0 (0.56)	0	0	0	0.2
SHEEP	0	1.0	---	---	---	---	---	0	0	0	0	0.9 (.98)	0	---	---	0.2

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES																
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP			---	---	---	---	---									
DOES vs CATTLE	---			---	---	---	---	---								
DOES vs SHEEP			---	---	---	---	---							---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---						---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.17a: MEAN PERCENTAGE ± SE (IN BRACKETS) OF OTHER FORB S IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0.4	0	1.5	0.3	1.9	2.2	0	1.3	0.5	0	7.4	1.2	2.4	0.5	2.8	
FALLOW DOES	5.5	4.5	2.5	1.0	7.3	5.5	4.5	2.5	4.1	11.7	1.0	0.4	2.2	2.2	3.0	
CATTLE		0	4.0						5.5	3.5	3.5	1.9	1.0	0.5	8.7	
SHEEP	2.4	1.4						1.9	0.5	6.8	5.7	3.6	2.1			

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)
BUCKS vs DOES	
BUCKS vs CATTLE	
BUCKS vs SHEEP	
DOES vs CATTLE	
DOES vs SHEEP	
CATTLE vs SHEEP	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.18 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF BROAD LEAVED TREE SPECIES IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	6.3 (1.4)	13.2 (0.9)	13.0 (3.4)	6.5 (2.4)	9.8 (1.3)	11.7 (1.8)	11.7 (2.8)	6.5 (1.7)	5.3 (1.1)	1.5 (0.5)	4.3 (0.5)	3.6 (1.7)	19.7 (2.9)	21.3 (2.0)	8.2 (2.1)	9.5
FALLOW DOES	15.0 (1.7)	15.0 (1.7)	5.0 (0.6)	9.5 (1.5)	6.8 (1.8)	13.0 (1.7)	13.0 (2.5)	6.5 (1.5)	15.5 (2.2)	8.8 (2.7)	16.0 (1.3)	14.8 (1.7)	6.2 (1.1)	2.7 (1.1)	3.1 (0.8)	9.9
CATTLE	---	6.4 (1.2)	10.5 (2.1)	---	---	---	---	---	9.5 (1.0)	4.5 (1.7)	3.5 (1.3)	1.0 (1.0)	8.0 (2.2)	18.5 (1.0)	20.5 (2.3)	9.2
SHEEP	6.6 (1.9)	3.8 (1.4)	---	---	---	---	---	16.2 (3.0)	7.5 (0.5)	3.8 (0.8)	3.4 (0.9)	2.3 (0.4)	6.3 (1.6)	---	---	6.3

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES	D**								D**		D***	D***	B***	B***		
BUCKS vs CATTLE	---	B**		---	---	---	---	---					B**		C***	
BUCKS vs SHEEP		B***	---	---	---	---	---	S*					B***	---	---	
DOES vs CATTLE	---	D**		---	---	---	---	---	D*		D***	D***		C***	C***	
DOES vs SHEEP	D**	D**	---	---	---	---	---	S*	D**		D***	D***		---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---						---	---	

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.19 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Taxus baccata* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0.9 (0.5)	5.9 (2.5)	15.8 (3.3)	14.8 (2.0)	15.4 (1.7)	18.5 (1.7)	8.7 (1.6)	1.4	0.4	1.0 (0.6)	1.7 (1.0)	5.4 (3.0)	4.7 (0.7)	5.1 (1.3)	22.7 (2.8)	5.9
FALLOW DOES	10.0 (2.2)	12.0 (1.8)	4.0 (1.8)	8.0 (2.4)	8.3 (0.8)	23.5 (2.1)	22.0 (1.4)	3.0	0	32.0 (1.3)	16.9 (3.4)	7.6 (1.0)	0.9 (0.5)	1.2 (0.4)	4.5 (1.3)	8.4
CATTLE	---	2.5 (1.5)	4.0 (0.8)	---	---	---	---	---	3.0 (0.6)	1.5 (0.5)	0	1.0	2.5 (1.3)	4.0 (1.4)	3.4 (1.3)	2.4
SHEEP	2.4 (1.5)	0	---	---	---	---	---	3.3 (2.0)	0.5	0	0	0.5	1.4 (1.3)	---	---	1.0

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)##															
BUCKS vs DOES				B*		D***				D***	D*		B**			B**
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP			---	---	---	---	---								---	---
DOES vs CATTLE	---			---	---	---	---	---								
DOES vs SHEEP			---	---	---	---	---								---	---
CATTLE vs SHEEP	---		---	---	---	---	---	---							---	---

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level
\# Comparisons made only for bucks and does (t-test).

Comparison made only for bucks and does

- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.20: MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Rubus* spp. IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0.9 (.52)	0	12.1 (1.45)	13.4 (4.3)	18.2 (1.3)	18.5 (0.9)	10.8 (1.7)	0	0	0	0	0	0	0	0	1.1
FALLOW DOES	0	0	0	2.0 (1.7)	1.9 (0.8)	2.5 (1.5)	1.5 (1.0)	0	0	0	0	0	0	0	0	0.5
CATTLE	---	0	0	---	---	---	---	---	0	0	0	0	0	0	0	0
SHEEP	0	0	---	---	---	---	---	0	0	0	0	0	0	---	---	0

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES					B***	B**	B*									
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP				---	---	---	---							---	---	
DOES vs CATTLE	---			---	---	---	---	---								
DOES vs SHEEP			---	---	---	---	---							---	---	
CATTLE vs SHEEP	---			---	---	---	---	---						---	---	

Comparison made only for bucks and does

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5.3.21 : MEAN PERCENTAGE ± SE (IN BRACKETS) OF *Mast* IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	0	3.2 (0.9)	18.1 (1.5)	3.7 (1.3)	0	0	0	0	0.4	0	0	0	0,4	0,9	6,8	3.2
FALLOW DOES	0	29.0 (4.1)	34.0 (1.8)	1.0 (0.6)	2.9	0	0	0	0	0	0	0	0	0	0	5.3
CATTLE	---	0.5	0	---	---	---	---	---	0.5	0	0	0	0	0	0	0.1
SHEEP	0	0	---	---	---	---	---	0	0	0	0	0	0	---	---	

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES		D**	D**													
BUCKS vs CATTLE	---			---	---	---	---	---								
BUCKS vs SHEEP			---	---	---	---	---								---	---
DOES vs CATTLE	---			---	---	---	---	---								
DOES vs SHEEP			---	---	---	---	---								---	---
CATTLE vs SHEEP	---		---	---	---	---	---	---							---	---

Comparison made only for bucks and does

Consumed more by :

B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

- - - ; Cattle/Sheep not present on the range
No Symbol ; Non-significant

APPENDIX 5.3.22: MEAN PERCENTAGE ± SE (IN BRACKETS) OF MOSS IN THE DIETS OF FALLOW BUCKS, DOES, CATTLE AND SHEEP

HERBIVORE SPECIES	SEPT. 1982	OCT.	NOV.	DEC.	JAN. 1983	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT. 1983	OCT. 1983	NOV. 1983	AVERAGE
FALLOW BUCKS	10.4 (1.4)	20.1 (2.2)	9.8 (1.2)	11.6 (2.4)	10.3 (1.2)	10.3 (0.9)	18.1 (1.7)	12.8 (1.1)	6.2 (1.2)	2.6 (0.5)	5.2 (1.3)	5.9 (1.1)	6.8 (1.7)	7.4 (0.1)	6.8 (2.3)	8.5
FALLOW DOES	9.0 (1.3)	3.0 (0.6)	9.0 (1.3)	18.0 (2.8)	16.0 (2.2)	18.5 (1.0)	17.5 (1.9)	18.0 (0.8)	7.4 (1.7)	6.3 (1.2)	3.8 (0.4)	9.4 (1.7)	5.3 (1.7)	2.7 (0.8)	2.2 (0.4)	6.9
CATTLE	---	10.9 (2.4)	24.5 (1.7)	---	---	---	---	---	12.5 (1.0)	10.5 (2.1)	4.5 (0.5)	6.4 (2.7)	9.5 (1.7)	25.5 (2.1)	22.0 (1.6)	14.0
SHEEP	8.5 (1.3)	19.1 (0.3)	---	---	---	---	---	18.6 (1.3)	19.5 (3.6)	16.3 (1.5)	3.3 (1.7)	13.5 (1.0)	17.6 (1.6)	---	---	14.6

COMPARISONS	STATISTICALLY SIGNIFICANT DIFFERENCES (ANALYSIS OF VARIANCE)															
BUCKS vs DOES		B^{***}				D^{**}		D^{**}		D^{*}				B^{*}		
BUCKS vs CATTLE	---	B^{**}	C^{***}	---	---	---	---	---		C^{***}				C^{***}	C^{***}	
BUCKS vs SHEEP			---	---	---	---	---	S^{**}	S^{***}	S^{***}		S^{**}	S^{***}	---	---	
DOES vs CATTLE	---	C^{**}	C^{***}	---	---	---	---	---						C^{***}	C^{***}	
DOES vs SHEEP		S^{***}	---	---	---	---	---		S^{**}	S^{***}			S^{***}	---	---	
CATTLE vs SHEEP	---		---	---	---	---	---	---	S^{*}	S^{**}		S^{**}	S^{**}	---	---	

Consumed more by :

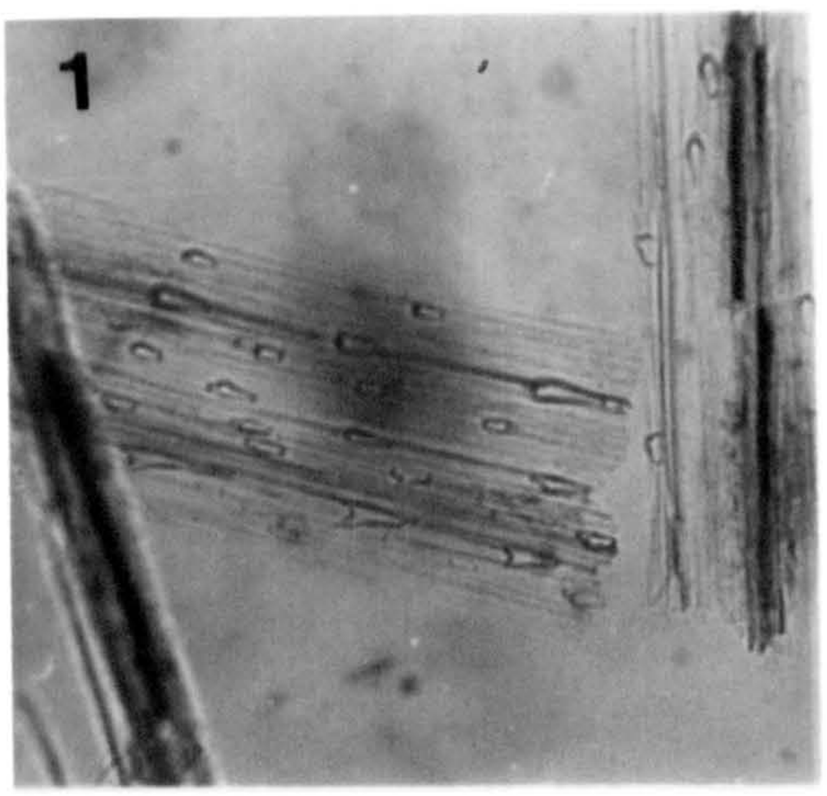
B = Bucks
D = Does
C = Cattle
S = Sheep

* Significantly different at 0.05 level
** Significantly different at 0.01 level
*** Significantly different at 0.001level

\- - - : Cattle/Sheep not present on the range
No Symbol : Non-significant

APPENDIX 5,4 List of photomicrographs of important food plant species consumed by the herbivores

1. *Agrostis tenuis*
2. *Agrostis tenuis*
3. *Dactylis glomerata*
4. *Dactylis glomerata*
5. *Deschampsia cespitosa*
6. *Deschampsia cespitosa*
7. *Cynosurus cristatus*
8. *Festuca rubra*
9. *Festuca rubra*
10. *Holcus lanatus*
11. *Lolium perenne*
12. *Lolium perenne*
13. *Poa trivialis*
14. *Cirsium vulgare*
15. *Trifolium repens*
16. *Trifolium repens*
17. *Quercus robur*
18. *Taxus baccata*(fruit)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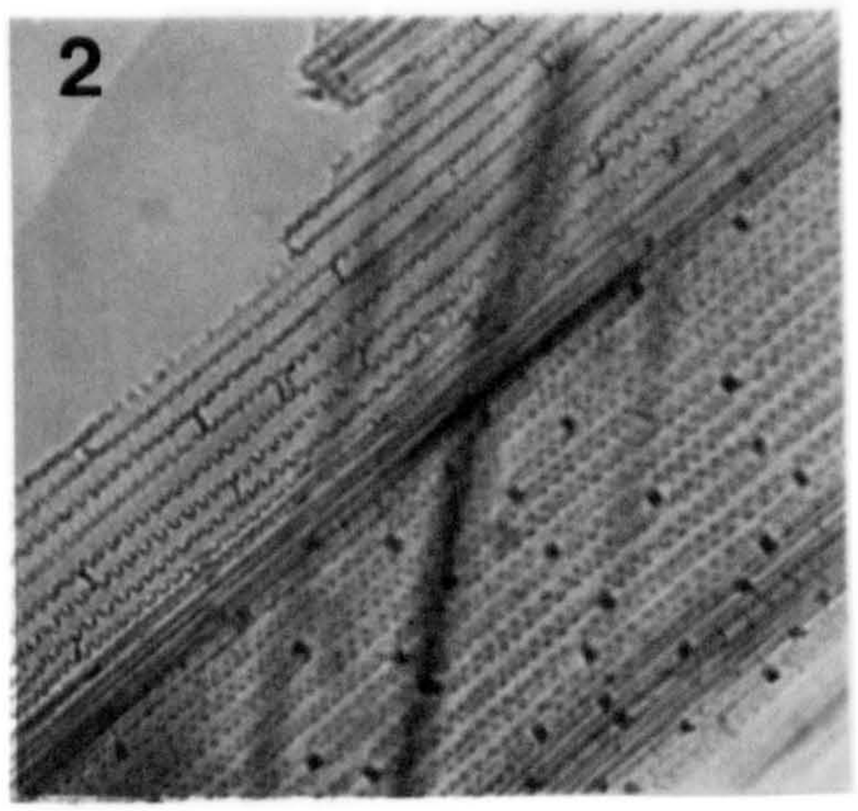
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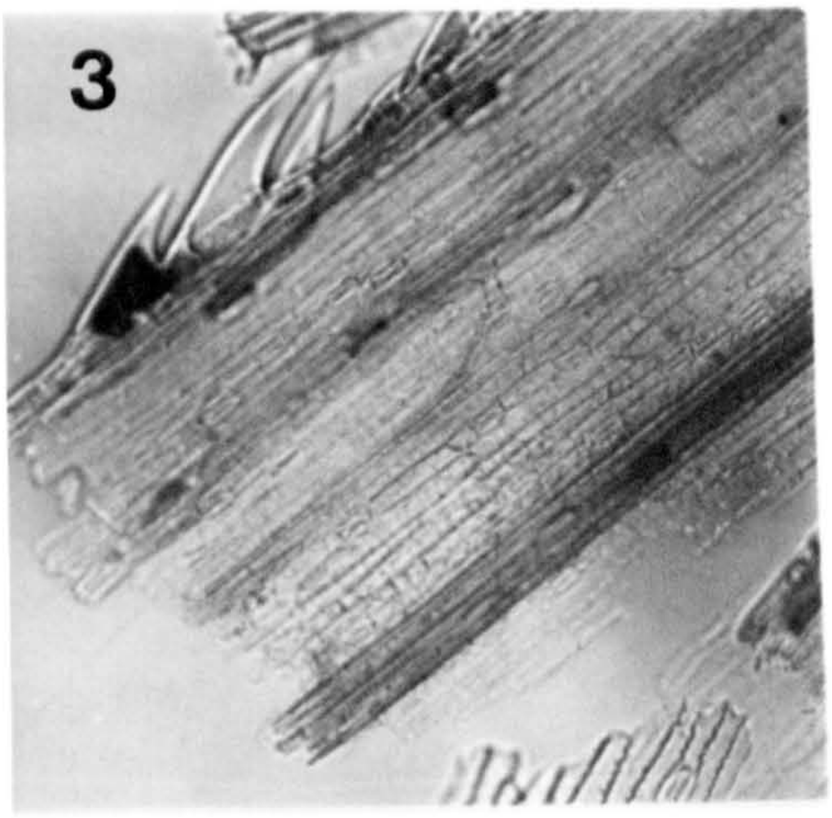
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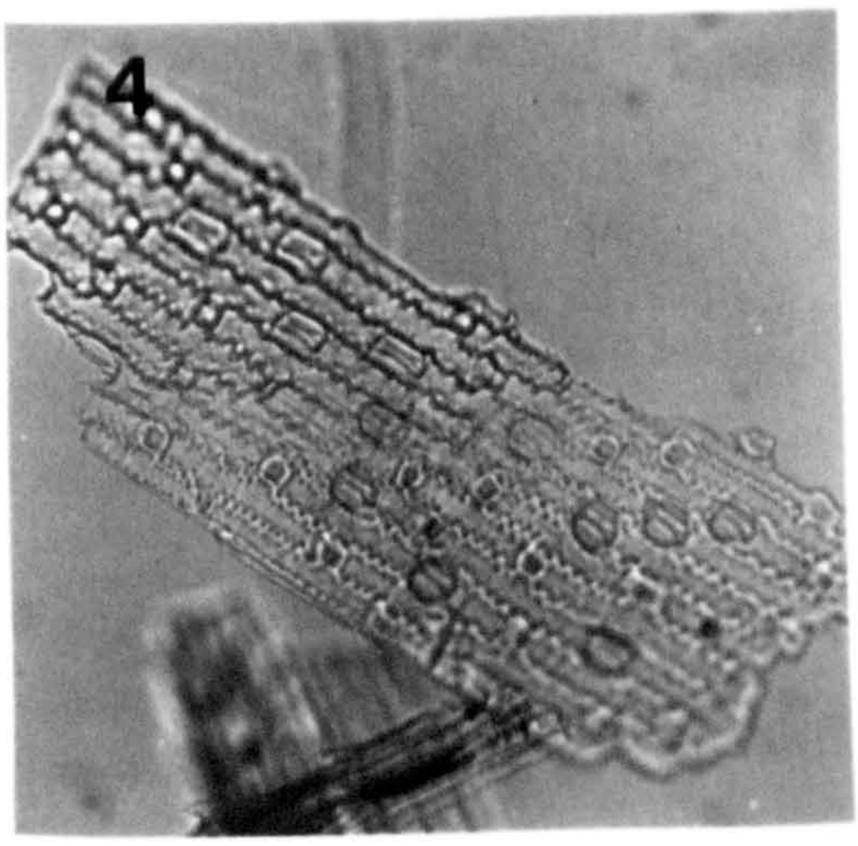
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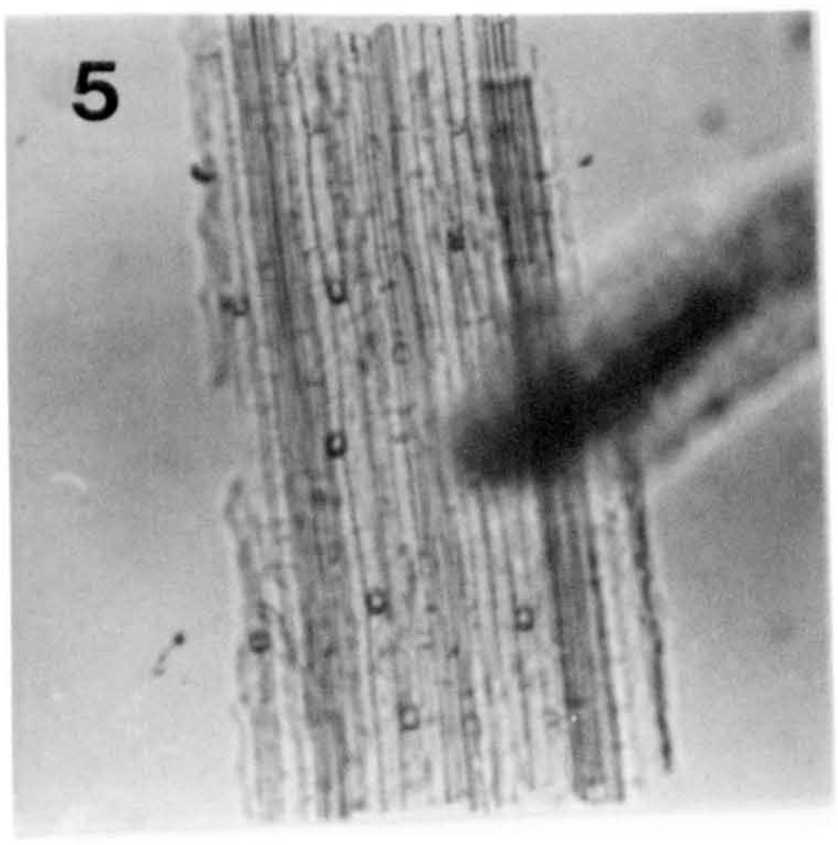
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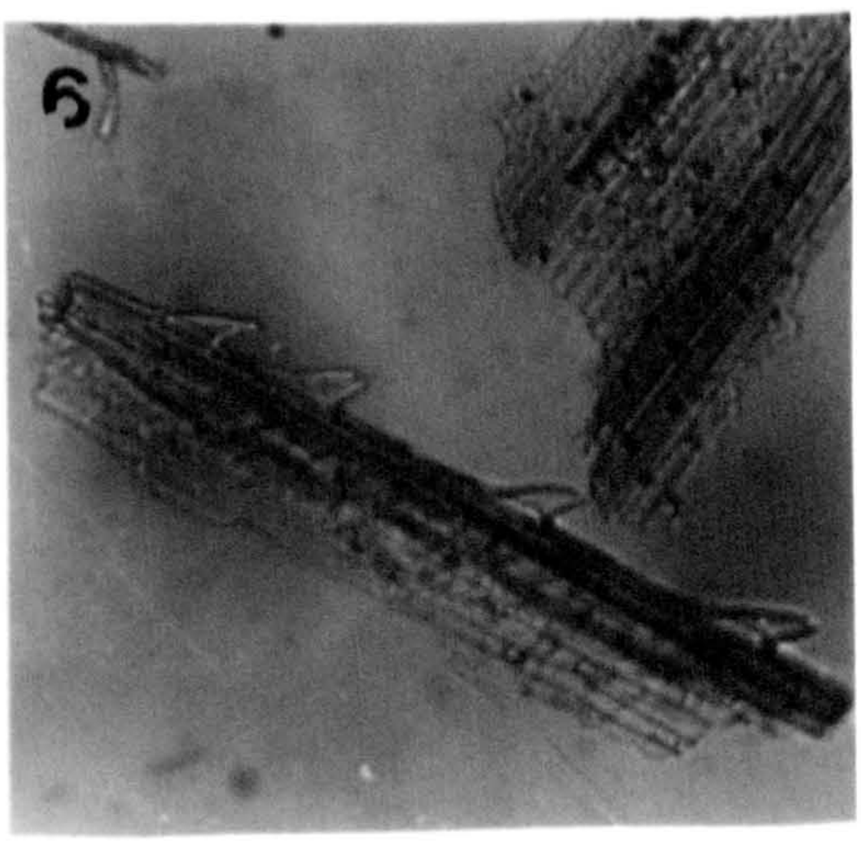
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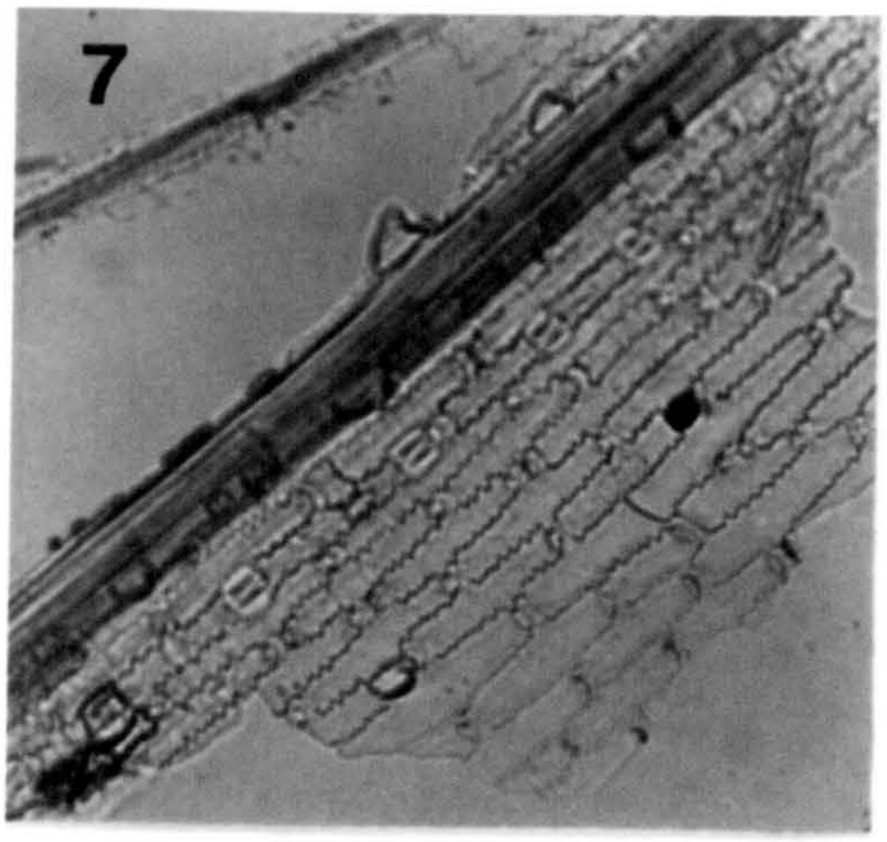
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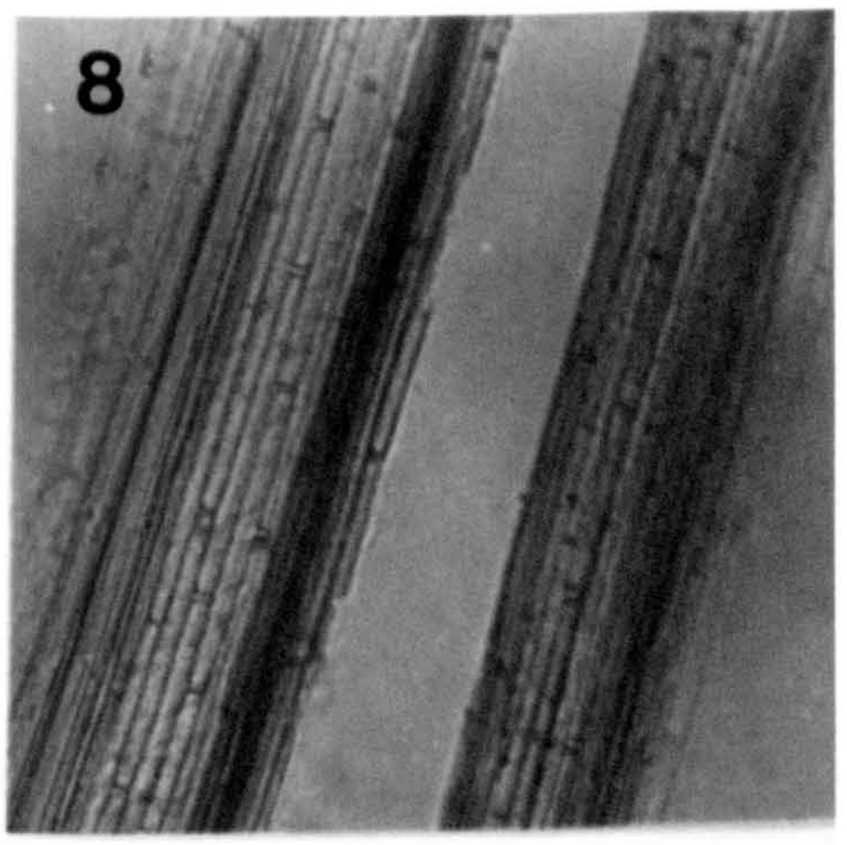
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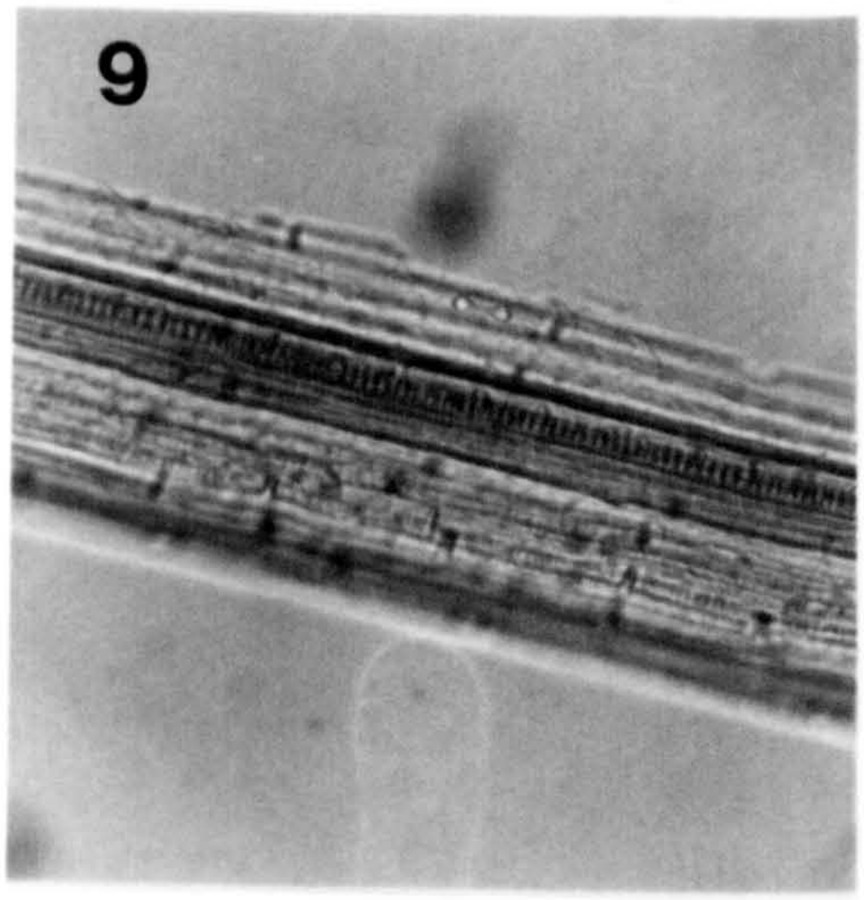
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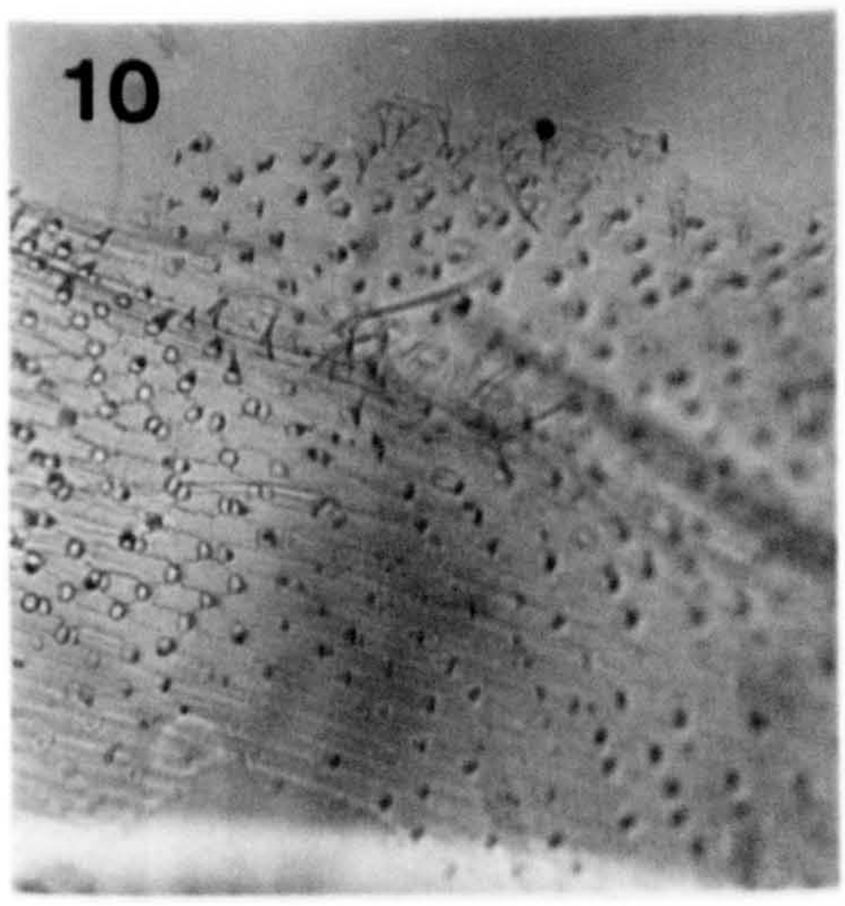
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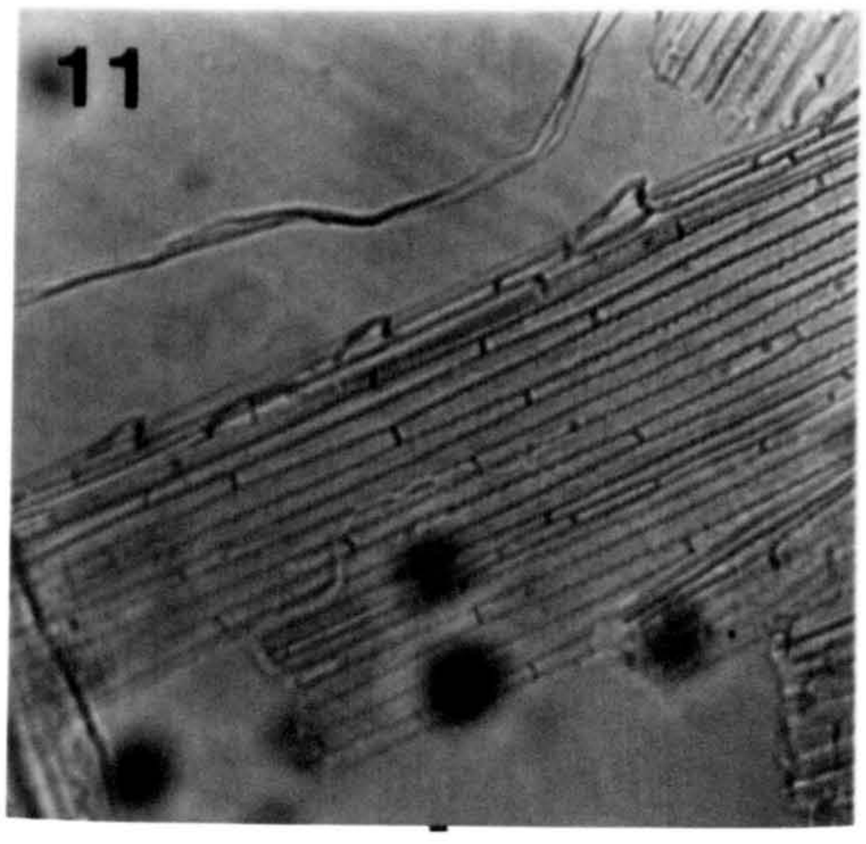
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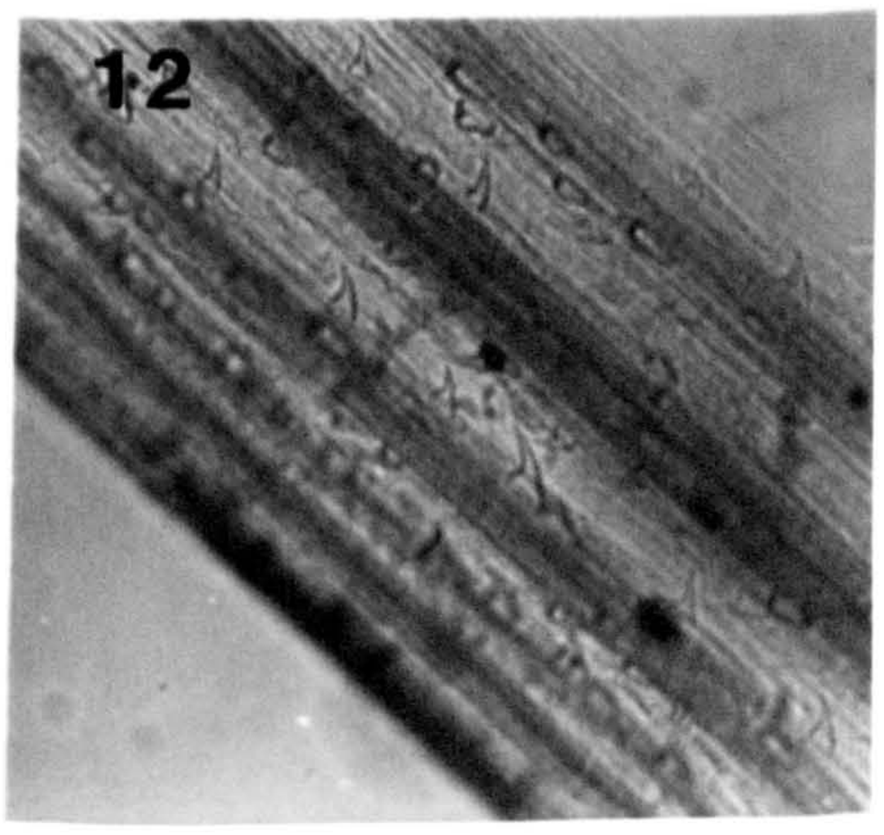
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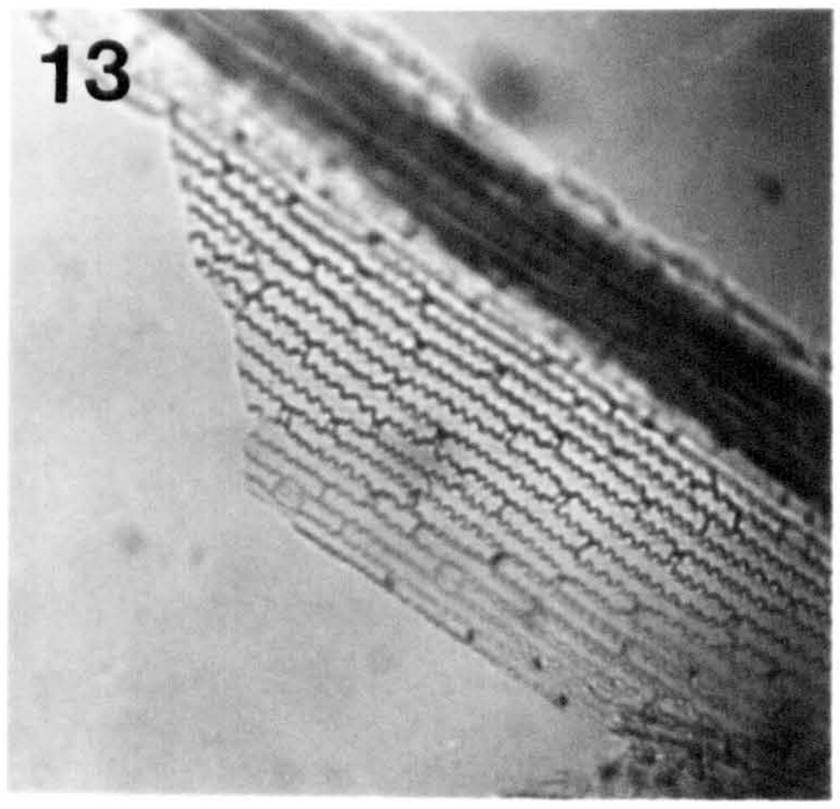
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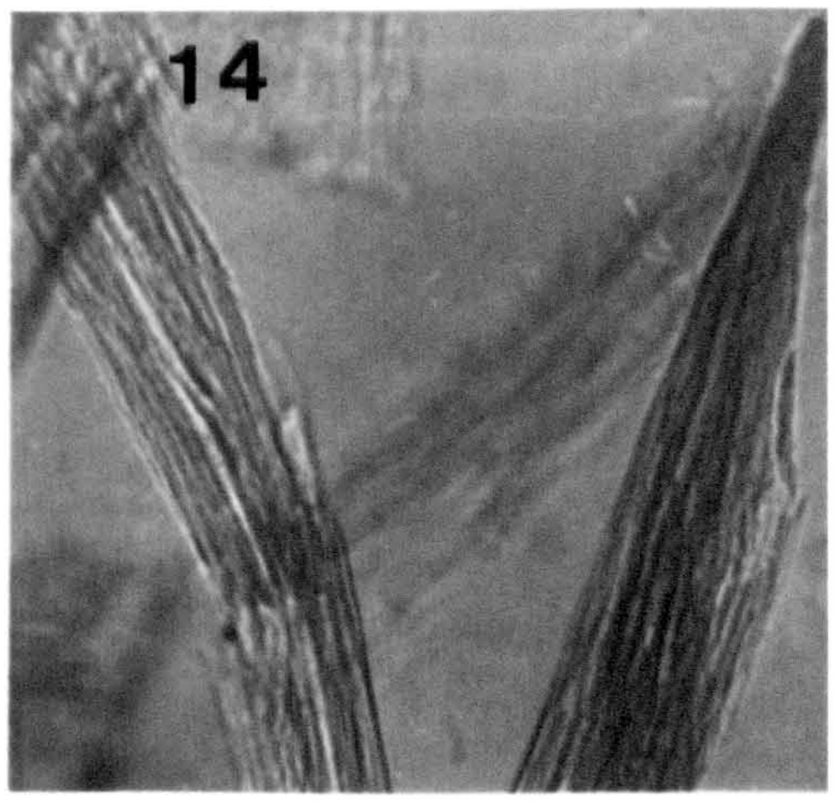
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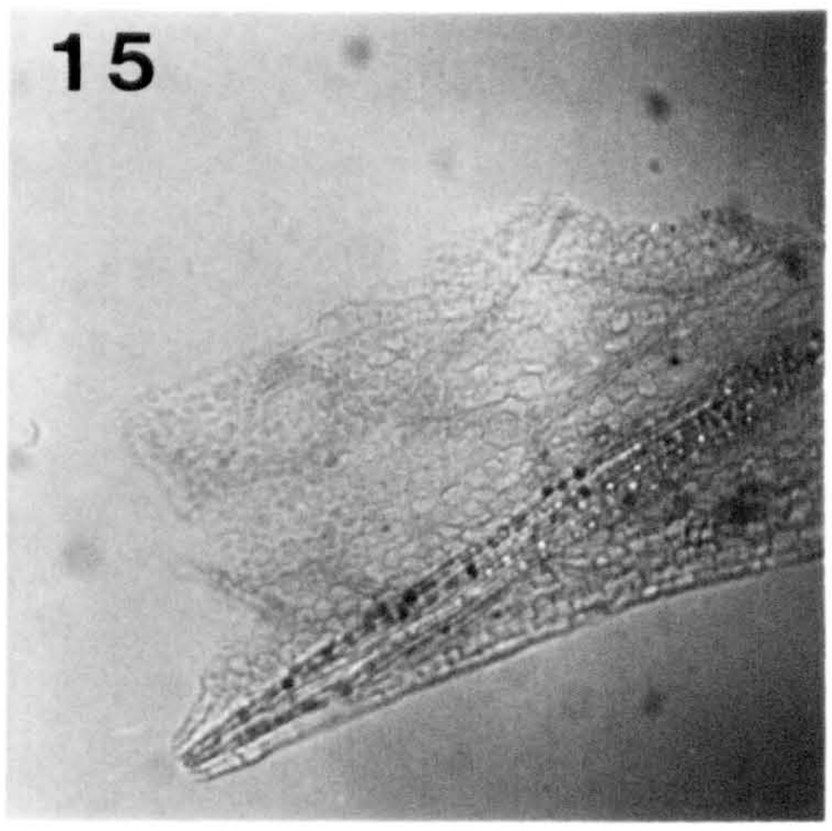
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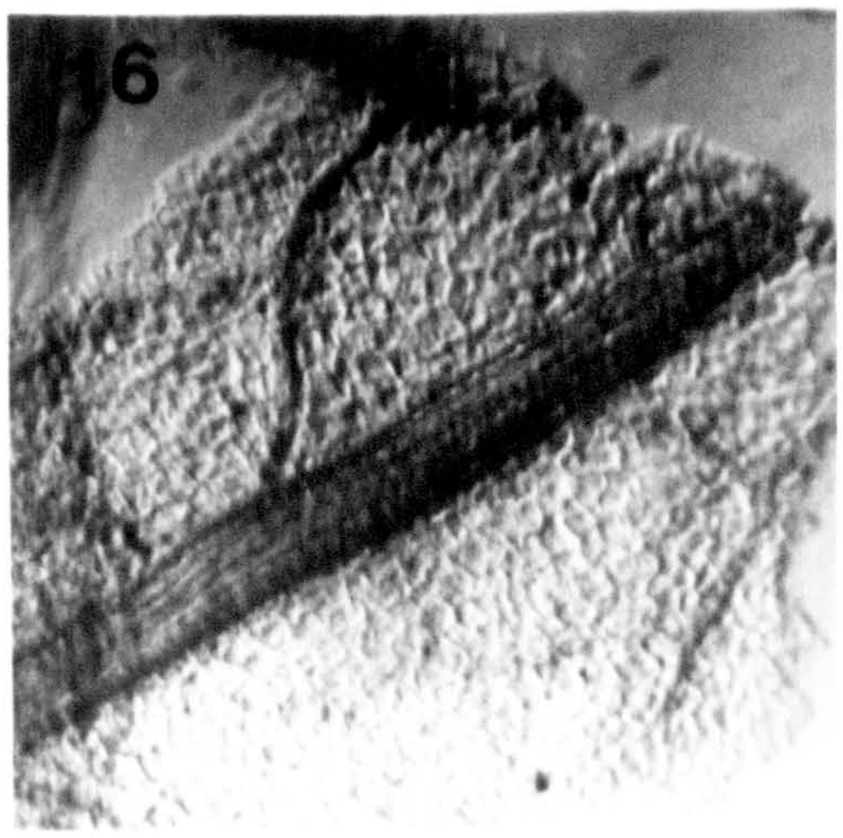
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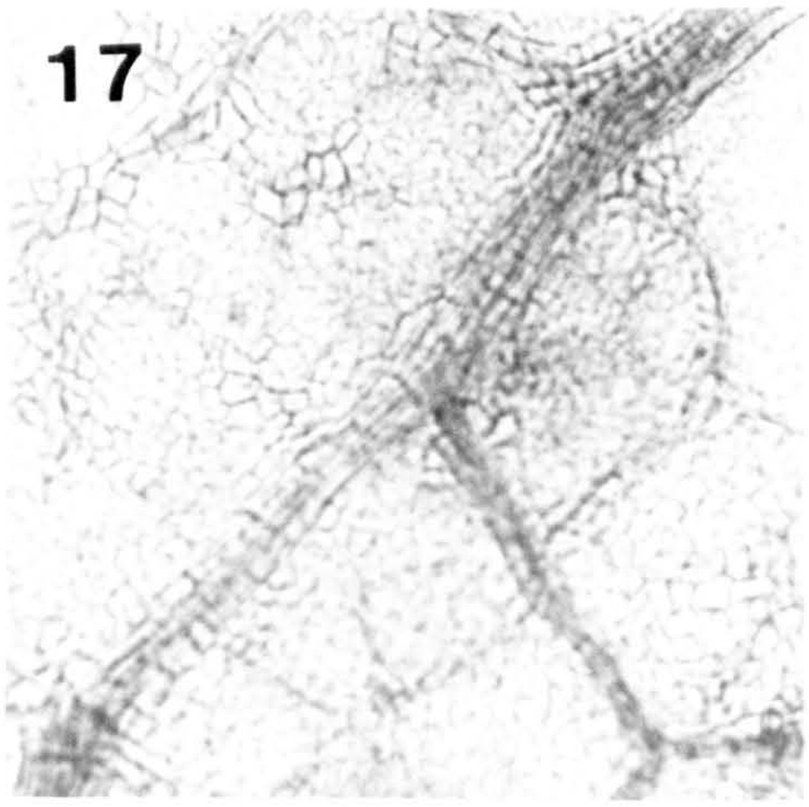
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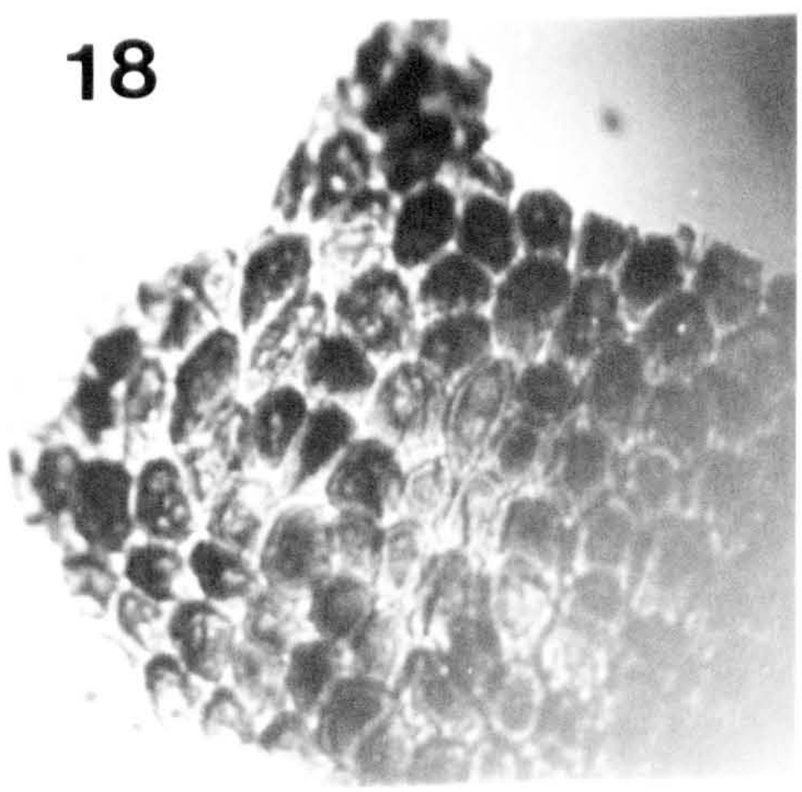
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